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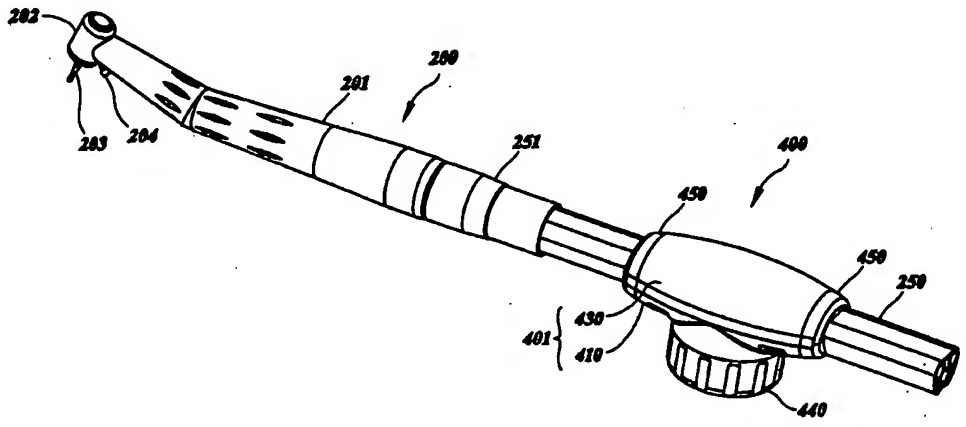

(57) Abstract

A filter is disposed along a flow path for fluid to be supplied to a dental patient's mouth. In preferred embodiments, the filter includes a microporous membrane, which may be capable of removing endotoxins or other pyrogens from fluid being filtered. The filter may be installed inside or outside a dental instrument. The filter improves the safety of dental procedures by preventing microorganisms and other undesirable substances from being introduced into a dental patient's mouth.

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FILTER FOR USE WITH A DENTAL INSTRUMENT

Background of the Invention

1. Field of the Invention

This invention relates to filters and filtering methods for the filtration of water, air, or other fluids supplied to hand-held dental instruments.

2. Description of the Related Art

Many hand-held instruments used in dental procedures are adapted to be connected to lines for supplying water, air, or other fluids to the mouth of a dental patient through the instrument. Examples of such instruments include dental syringes, handpieces (devices which rotate a member such as a drill or a polishing brush), sonic scalers, ultrasonic scalers, and air abrasion instruments.

The water which is supplied to the patient's mouth via such water lines is usually ordinary tap water or other non-sterilized source water. It has been discovered that the interior surfaces of water lines are conducive to the formation of a film (known as a biofilm) of biological contaminants such as bacteria or other microorganisms. When water passes through the water line, microorganisms or other matter may be picked up from the biofilm and carried into the patient's mouth. Microorganisms from the biofilm can be particularly harmful to a patient with a compromised immune system, but they may be dangerous even to healthy patients, since bleeding which frequently accompanies even minor dental procedures creates an easy pathway for the microorganisms to enter the patient's bloodstream. Accordingly, there is significant interest in controlling biofilms and associated contamination in water lines for hand-held dental instruments in order to prevent microorganisms and other harmful substances contained in the water lines from reaching the patient. For these reasons, it is desirable to filter water or other liquids which are supplied to patients via dental instruments. In some cases, it may also be desirable to filter air to be supplied to patients during dental procedures.

Various water and air filters have been proposed for use with dental instruments, but existing filters tend to have various drawbacks, such as being bulky

and interfering with the operation of the dental instruments, being located too far from the downstream end of a water line so that biofilms can form and bacteria can grow downstream of the filter, or requiring replacement of the entire filter whenever the filter medium requires replacement. Furthermore, conventional filters for dental instruments do not have the capability of removing endotoxins or other pyrogens from the fluids being filtered.

Summary of the Invention

The present invention provides a filter for use with a dental instrument which can reduce or prevent the formation of biofilms in locations downstream of the filter and thereby prevent the introduction of biological contamination into dental instruments.

The present invention also provides a filter for use with a dental instrument which does not interfere with the use of the dental instrument.

The present invention further provides a filter for use with a dental instrument having a filter element which can be easily replaced while enabling the remainder of the filter to be reused.

The present invention additionally provides a filter for use with a dental instrument which is capable of removing endotoxins or other pyrogens from fluids passing through it.

The present invention also provides a filter for use with a dental instrument which can prevent the formation of a vapor lock due to bubbles present in a fluid being filtered.

The present invention yet further provides a dental instrument which can internally receive a filter element.

The present invention also provides an arrangement for dental procedures including a dental instrument and a filter associated with the dental instrument for filtering a fluid to be dispensed into a dental patient's mouth through the dental instrument.

The present invention additionally provides methods of using a dental instrument and of filtering a fluid to be supplied to a dental patient's mouth via a dental instrument.

A filter according to the present invention may include various components.

Typically, the filter will include a filter medium for removing one or more selected substances from a fluid to be filtered. It may also include components such as a housing for accommodating the filter medium, one or more sealing members for forming a seal between components of the filter or between the filter and another member, and support members. When the filter medium is part of a replaceable unit intended to be removably installed in a housing or other member, the unit may be referred to as a filter element.

A filter according to the present invention can be used to filter a variety of fluids, including liquids, gases, and multi-phase mixtures. In preferred embodiments, a filter according to the present invention is used to filter water and/or air, but it may be used to filter any other fluids to be dispensed into a dental patient's mouth as part of a dental procedure.

A filter according to the present invention is not restricted to use with any particular type of dental instrument, and in general is suitable for use with any dental instrument by which fluid can be supplied to a patient's mouth. For example, the filter can be used with dental syringes, handpieces, sonic scalers, ultrasonic scalers, and air abrasion instruments. Similarly, a dental instrument according to the present invention may be any known type of dental instrument having one or more fluid passages extending through it.

According to one aspect of the present invention, a filter medium of a filter according to the present invention may be one which is positively charged in water and capable of removing endotoxins or other pyrogens from fluid passing therethrough. The use of a positively charged medium provides the filter with excellent ability to protect dental patients against biological contamination.

According to another aspect of the present invention, a filter medium of a filter according to the present invention may be one having a hydrophilic region and a hydrophobic region through which air in water being filtered can pass. The provision of a hydrophobic region prevents gas bubbles present in water being filtered from forming a vapor lock on the upstream surface of the filter medium.

In preferred embodiments, a filter according to the present invention comprises a filter element which can be removably installed within another member, such as a dental instrument or a housing of the filter. The ability of the filter element to be readily installed in or removed from the housing or other member allows the

filter element to be easily replaced while allowing the housing or other member accommodating the filter element to be reused. This lowers operating costs and gives a dental practitioner an incentive to replace the filter element at frequent intervals, thereby increasing the cleanliness and safety of dental procedures. However, a filter according to the present invention is not restricted to one comprising a removable filter element.

A filter according to the present invention can be installed in a variety of locations with respect to a dental instrument, such as within a dental instrument, on the exterior of the dental instrument, or upstream of the dental instrument in-line with tubing for supplying fluid to the dental instrument.

According to one aspect of the present invention, a dental instrument is adapted to accommodate one or more filter elements within its interior along a fluid path passing through the dental instrument. In preferred embodiments, a dental instrument includes a handle with first and second sections between which one or more filter elements may be disposed. For example, the sections of the handle may be hinged to each other for movement between an open and a closed position, or they may be capable of moving axially with respect to each other between an open and a closed position.

When a filter according to the present invention is installed outside a dental instrument, the filter will frequently include a housing in which a filter medium can be accommodated. In preferred embodiments, a housing of a filter is capable of being opened and closed to permit a filter medium to be readily replaced. In one preferred embodiment, the housing of a filter according to the present invention can fit around tubing through which fluids can be supplied to a dental instrument. Since the housing can fit around tubing, the filter takes up very little space and is unobtrusive, and its presence does not interfere with the use of the tubing or a dental instrument to which the tubing is connected. In other embodiments, a housing may be connected in series with tubing without the tubing passing through the housing.

These and other aspects of the present invention will be explained in further detail by the following description and the accompanying drawings.

Brief Description Of The Drawings

Figure 1 is a side elevation of an embodiment of a dental syringe according to

the present invention equipped with an internal filter element.

Figure 2 is a longitudinal cross-sectional view of a portion of the handle of the dental syringe of Figure 1 in an open state.

Figure 3 is a longitudinal cross-sectional view of a portion of the handle of another embodiment of a dental syringe according to the present invention.

Figure 4 is a cutaway isometric view of one of the filter elements employed in the embodiments of Figures 1 - 3.

Figure 5 is an exploded isometric view of another embodiment of a dental syringe according to the present invention.

Figure 6 is a cutaway, partially exploded, isometric view of a dental syringe equipped with an embodiment of a filter according to the present invention.

Figure 7 is a cutaway exploded isometric view of the dental syringe and filter of Figure 6.

Figure 8 is a cutaway exploded isometric view of the dental syringe and filter of Figure 6 from another angle.

Figure 9 is a cutaway side elevation of the dental syringe and filter of Figure 6.

Figure 10 is an isometric view of a high-speed handpiece equipped with another embodiment of a filter according to the present invention.

Figure 11 is an exploded isometric view of the filter of Figure 10.

Figure 12 is a cutaway exploded isometric view of the filter of Figure 10 from another angle.

Figure 13 is an isometric view of another embodiment of a filter according to the present invention connected to a high-speed handpiece.

Figure 14 is an exploded cross-sectional isometric view of the embodiment of Figure 13.

Figure 15 is a longitudinal cross-sectional view of the embodiment of Figure 13 in an assembled state.

Figure 16 is an isometric view of another embodiment of a filter according to the present invention connected to a high-speed handpiece.

Figure 17 is an exploded longitudinal cross-sectional view of the embodiment of Figure 16.

Figure 18 is an isometric view of a handpiece equipped with another

embodiment of a filter according to the present invention.

Figure 19 is an exploded view of the filter of Figure 18.

Figure 20 is a bottom view of the lower portion of the body of Figure 18.

Figure 21 is an isometric view of the filter of Figure 18 with the upper portion of the filter removed.

Figure 22 is a cutaway isometric view of the filter of Figure 18 with the upper portion of the filter removed and with the tubing raised above the lower portion of the filter.

Figure 23 is a transverse cross-sectional view of the filter of Figure 18 with the upper portion of the filter removed.

Description of Preferred Embodiments

Figure 1 illustrates an embodiment of a dental instrument according to the present invention which can be internally equipped with one or more filters according to the present invention in the form of replaceable filter elements. The dental instrument is in the form of a dental syringe 10, but it may be of any other type, such as a handpiece or a scaler. The illustrated syringe 10 is of a type for supplying air and water to the mouth of a patient, but it may instead be of a type for supplying only air, only water, or one or more other fluids. The syringe 10 includes a handle 11, a valve head 21 mounted on one end of the handle 11, and a syringe tip 23 which is mounted on the handle 11 and through which air and/or water can be discharged into a patient's mouth. The handle 11 includes internal fluid passages (sometimes referred to as lumens) for water and air which are connected to tubing 25 including a water line 26 and an air line 27 respectively connected to corresponding sources of water and compressed air. The valve head 21, which may be of conventional structure, contains unillustrated valves which are operated by corresponding buttons 22 (only one of which is shown) on the valve head 21 and which permit or prevent fluid communication between the fluid passages in the handle 11 and corresponding passages in the syringe tip 23. The syringe tip 23 may be of conventional structure. Typically, it is designed to be readily detachable from the valve head 21 to enable the syringe tip 23 to be cleaned or replaced when desired.

The handle 11 has a structure which enables it to be opened and closed to permit one or more filter elements to be inserted into the handle 11 in line with one

or both of the internal passages for fluids. In this embodiment, the handle 11 is divided into two sections 12 and 17 connected by a hinge 20 about which the sections can be pivoted between a closed position (shown in Figure 1) and an open position (shown in cross section in Figure 2). When the handle 11 is closed, the filter elements are sandwiched between and fluidly sealed to the sections 12 and 17 by compression, whereas when the handle 11 is open, the filter elements are accessible and so can be easily removed from inside the handle 11 and replaced. As shown in Figure 2, the first section 12 of the handle has an internal passage for water 13 and an internal passage for air 15. The upstream ends of the passages 13 and 15 communicate with the tubing 25 and the downstream ends open onto the end surface of the first section 12. Similarly, the second section 17 of the handle has an internal passage for water 18 and an internal passage for air 19, with the upstream ends of both passages opening onto the end surface of the second section 17 and the downstream ends communicating with the valve head 21 of the syringe 10.

One or both sections of the handle 11 may include recesses for receiving the filter elements. In the present embodiment, two recesses 14 and 16, each of which is sized to receive a corresponding filter element, are formed in the first section 12 of the handle 11 at the downstream ends of the passage for water 13 and the passage for air 15. The seal between the sections 12 and 17 of the handle 11 and the filter elements when the handle 11 is closed prevents the fluids to be filtered from bypassing the filter elements. The handle 11 can be releasably locked in its closed position by a suitable member, such as a latch or a movable ring which can be slid over the joint between the two sections 12 and 17. The opposing surfaces of the two sections 12 and 17 are shown as extending non-perpendicularly with respect to the longitudinal axis of the handle 11 to increase the area of the opposing surfaces, but the surfaces may instead be perpendicular to the axis.

In the present embodiment, the handle 11 is equipped with a filter element 45 for water and another filter element 48 for air, although one of the filter elements may be omitted if desired. Furthermore, in situations in which the fluids passing through the handle 11 do not require filtration, both filter elements 45, 48 can be removed and the dental syringe 10 can be used in the manner of a conventional dental syringe.

Figure 4 illustrates an example of the water filter element 45. The air filter

element 48 may have a similar structure. The filter element 45 includes a filter medium 46, and it may also include a sealing ring 47 which is sealed to the filter medium 46 and extends around the outer periphery of the region of the filter medium 46 through which fluid passes during filtration. The illustrated filter element 45 is round, but it may have any other desired shape which enables it to be installed in the handle 11, such as semicircular, oval, or polygonal.

The filter medium 46 of the filter element 45 for water can be any material capable of removing microorganisms or other substances requiring removal from the water passing through it. The filter medium 46 need not have any particular structure. For example, depending upon the materials which it is desired to remove from the fluid being filtered, meshes, fibrous media, filter papers, woven or non-woven sheets, and membranes may be employed as the filter medium, or a plurality of these or other filter materials may be used in combination. Frequently, a microporous membrane is suitable as the filter medium 46. The term microporous membrane is used to refer to a thin sheet, generally formed from a synthetic material, having a substantially uniform, continuous matrix structure containing numerous pores typically ranging from about 10 micrometers to about 0.01 micrometers in diameter. A self-wetting hydrophilic microporous membrane is particularly suitable since it can be immediately used for filtration of water upon installation in the handle 11 without having to be pre-wet to enable water to pass through it. When the filter medium 46 is a microporous membrane, it preferably has a maximum pore size less than 1 μm, and when freedom from all microbial contamination in the filtrate is desired, the membrane preferably has a pore size of 0.45 μm or smaller. Since virtually all bacteria, endotoxins and other pyrogens, and viruses have a negative charge in tap water or other source water, microporous membranes having a positive charge in tap water are particularly preferred because they are very effective for removal of such negatively-charged biological materials, although microporous membranes which are not positively charged may also be employed. Examples of suitable positively-charged microporous membranes include but are not limited to positively-charged polyethersulfone membranes available from Pall Gelman Sciences under the trademark SUPOR. Positively-charged nylon 66 membranes available from Pall Corporation under the trademark POSIDYNE may also be suitable. Other examples of membranes which may be suitable for use in the present invention include those

described in U.S. Patents No. 4,340,479, No. 4,702,840, No. 5,151,189, and No. 5,269,931.

The filter medium 46 may comprise a single layer, or it may comprise a plurality of layers of the same or different filtering properties. The filter medium may have a substantially uniform structure (e.g., a pore size or pore rating) throughout its thickness, or the pore structure may vary in a continuous, discontinuous, or stepwise manner. Having a varied pore structure (such as a decreasing pore size along the fluid flow path) may contribute to lowering the differential pressure across the filter medium 46 and may permit the filter element to be used longer without blocking or plugging by removing larger particles upstream and thus preventing blockage of smaller downstream pores. A single layer of filter medium may have a varying pore size over its thickness, or a plurality of layers of different pore size (each layer having a substantially constant pore size over its thickness) can be combined, with the layers having the coarse pore size being on the upstream side of the medium and the layers having a finer pore size being on the downstream side of the medium.

The filter medium of the filter element 48 for air may likewise have any structure which enables it to remove undesirable substances from air passing through it, with a hydrophobic microporous membrane having a maximum pore size of less than 1 μm being particularly suitable. As is the case with respect to the water filter element 45, if complete freedom from microbial contamination is desired, a microporous membrane for use as the air filter element 48 preferably has a pore size of less that 0.45 μm. Examples of suitable microporous membranes for use in the air filter element 48 include but are not limited to those available from Pall Gelman Sciences under the trademark VERSAPOR. PTFE microporous membranes are also suitable.

At times, air bubbles may be present in the water line 20. Such air bubbles may be due, for example, to air present in the water line 20 prior to the introduction of water into it, or to air which is already present in the water introduced into the water line 20. In order to prevent these air bubbles from forming a vapor lock on the upstream surface of the water filter element 45, the filter medium 46 for the water filter element 45 may contain one or more hydrophobic regions through which the air bubbles can be vented to the downstream side of the water filter element 45.

The sealing ring 47 may have any structure which enables it to be sealed to the filter medium 46 and the interior of the handle 11 to prevent fluid being filtered from bypassing the filter medium 46. For example, the sealing ring 47 may comprise an O-ring or a gasket. The sealing ring 47 preferably extends around the region of the filter medium 46 through which fluid flows during filtration, but it is not necessary for the sealing ring 47 to completely enclose the periphery of the filter medium 46, i.e., the sealing ring 47 may be situated atop the filter medium 46 rather than containing the plane of the filter medium 46. The sealing ring 47 may comprise a single layer, or it may comprise a plurality of layers between which the filter medium 46 is sandwiched.

The sealing ring 47 may be attached to the filter medium 46, if desired, by a variety of methods, depending upon the materials of which the filter medium 46 and the sealing ring 47 are formed, including but not being limited to adhesive bonding, ultrasonic welding, and injection molding of the sealing ring 47 around the filter medium 46. An example of an efficient method of forming a plurality of filter elements 45 simultaneously is as follows. A plurality of spaced holes are cut in a sheet of gasket material, each hole having a diameter corresponding to the desired inner diameter of the sealing ring 47 of a filter element. The sheet of gasket material with the holes formed in it is then bonded to a sheet of the filter medium with an adhesive applied to one surface of the sheet of gasket material. A plurality of filter elements 45 are then cut to a final shape by cutting around each of the holes through both the gasket material and the filter medium. The process of cutting the holes in the gasket material, bonding the gasket material to the filter medium, and then cutting the filter elements to a final shape can be performed using a conventional flexographic printing machine, for example, equipped with a rotary die for carrying out the cutting operations.

It is convenient if the filter medium 46 is permanently attached to the sealing ring 47 so that the two can be handled as a single unit. However, in cases in which it is difficult to attach the filter medium 46 to the sealing ring 47, they may be separate members which are individually installed in a dental instrument, with a seal being formed between the filter medium 46 and the sealing ring 47 by compression. In some cases, it may be possible to omit the sealing ring 47 and form a seal around the filter medium 46 by direct contact between the filter medium 46 and an internal

surface of the handle 11 of the dental instrument. The filter element 45 may include components other than a filter medium and a sealing ring, such as a porous support layer for providing support to one or both of the upstream and downstream sides of the filter medium 46, a porous protective layer for protecting one or both sides of the filter medium 46 during handling, a prefilter, or a support frame which extends around the periphery of the filter element 45 to give it rigidity and which can seal against the sealing ring 47.

When the filter medium 46 of the water filter element 45 includes a hydrophilic region and a hydrophobic region, the size of the hydrophobic region is not critical. Examples of a suitable size are at most approximately 25% of the total surface area of the filter medium 46 which is exposed to fluid, more preferably at most approximately 15%, and still more preferably approximately 5% to approximately 10%. The hydrophobic region may also be larger than 25% of the total surface area of the filter medium 46, as long as the hydrophilic region of the filter medium 46 is larger enough for the desired flow rate of water through it. There may be a single hydrophobic region, or a plurality of hydrophobic regions may be dispersed over the surface area of the filter medium to prevent air bubbles from accumulating at a portion of the filter medium remote from a hydrophobic region. When there are a plurality of hydrophobic regions, their total surface area preferably falls into the ranges given above. The hydrophobic and hydrophilic regions may comprise different materials which are joined to each other, or they may comprise a single material which is treated locally to alter its properties. For example, a hydrophobic solution can be locally applied to a hydrophilic filter medium to produce hydrophobic regions on the filter medium, with the remainder of the filter medium remaining hydrophilic. Methods and materials for producing such a hydrophobic region are well known in the art. When the filter medium comprises polyethersulfone, as does the above-mentioned SUPOR membrane, an example of a suitable hydrophobic solution comprises silicone in an isopropyl alcohol carrier. The hydrophobic solution can be conveniently applied by methods including the striping method and the spotting method. In the striping method, the hydrophobic solution is applied to the membrane in a continuous manner while the membrane and a dispensing head for the hydrophobic solution undergo relative movement to produce a stripe having hydrophobic properties on the membrane. In the spotting method, the

hydrophobic solution is dispensed to form one or more discrete spots of hydrophobic character on the hydrophilic membrane.

Some microporous membranes have a preferred orientation with respect to the fluid being filtered, i.e., superior results are obtained if a specific side of the medium faces upstream. The sealing ring 47 may be shaped so as to permit the filter element 45 to be inserted into the handle of the dental instrument with only a single orientation. For example, the sealing ring 47 may be formed with two outwardly extending tabs of different sizes or shapes, and the handle may be formed with two recesses for receiving the tabs, with one of the recesses having a size or shape so that it can receive only a specific one of the tabs. With such an arrangement, the filter element 45 can be inserted into the handle only if each tab is located in the correct recess, at which time the filter medium 46 assumes the desired orientation with respect to the fluid to be filtered.

A handle containing a filter element is not limited to one having a hinged structure. Figure 3 is a longitudinal cross-sectional view of a portion of a handle 30 of another embodiment of a dental syringe according to the present invention having first and second sections 31 and 36 which can be moved axially with respect to each other between an open position (shown in Figure 3) in which the sections 31, 36 are spaced from each other to enable one or more filter elements 45, 48 to be installed between them, and a closed position in which the sections 31 and 36 abut each other and the filter elements are sandwiched between and sealed against the sections 31, 36. The first section 31 is adapted to be connected to conventional tubing for supplying air and water to the handle 30, and the second section 36 is adapted to be connected to a valve head of the syringe of which the handle 30 is a part. In this embodiment, the first section 31 contains an internal passage for water 32 and an internal passage for air 34, the upstream ends of both passages fluidly communicating with tubing for supplying air and water to the handle 30 and the downstream ends opening onto the end surface of the first section 31 opposing the second section 36. The second section 36 likewise has an internal passage for water 37 and an internal passage for air 38, the upstream ends of both passages opening onto the end surface of the second section 36 opposing the first section 31, and downstream ends fluidly communicating with the valve head of the syringe. Recesses for receiving filter elements 45, 48 may be formed in one or both of the end surfaces of the two sections 31, 36. In this

embodiment, recesses 33 and 35 are formed in the end surface of the first section 31 at the downstream ends of internal passages 32 and 34 for receiving the water filter element 45 and the air filter element 48, respectively.

The two sections 31, 36 can be maintained in their closed state in which they are sealed against the filter elements 45, 48 by any suitable arrangement, such as a snap fit, a bayonet fit, threaded engagement, or a clamp. In the present embodiment, a retaining nut 40 is rotatably mounted on the end of the first section 31, and external threads 39 capable of engaging with the internal threads of the retaining nut 40 are formed on the end of the second section 36 of the handle 30. The retaining nut 40 is prevented from coming off the first section 31 by a retaining ring 41 which is press fit over the end of the first section 31 inside of the retaining nut 40. When the retaining nut 40 is engaged with the external threads 39 of the second section 36, and tightened, the opposing ends of both sections 31, 36 are urged axially into sealing contact with the filter elements 45, 48 so that the fluid can flow from the internal passages 32, 34 in the first section 31 into the corresponding internal passages 37, 38 in the second section 36 through the corresponding filter elements without leaking to the exterior of the handle 30.

A dental instrument having filter elements for fluids disposed within its handle can be the same size as a conventional dental instrument, so the presence of the filter elements does not affect the ease of use of the dental instrument. The filter elements are readily accessible simply by opening the handle, so the user of the dental instrument will be motivated to replace the filter elements at frequent intervals, and as often as once per patient, thereby making it easy to maintain the fluids discharged from the dental instrument free of biological contamination.

Figure 5 is an exploded perspective view of another embodiment of a dental syringe 50 in which a single filter element 80 disposed in a handle 51 of the dental syringe 50 is capable of filtering a plurality of different fluids, such as both water and air. The handle 51 has first and second sections 52 and 60, each of which contains an internal passage for water and an internal passage for air to be supplied to the valve head 65 of the syringe 50. Like the valve head 21 of the syringe 10 of Figure 1, the valve head 65 of this embodiment includes one or more buttons 66 for operating corresponding valves within the valve head 65 and a syringe tip 70 detachably mounted on it. The two sections 52, 60 can be joined to each other so

that each passage in one section can communicate through the filter element 80 with the corresponding passage in the other section of the handle 51.

The filter element 80 includes a first filter medium 81 for filtering water and a second filter medium 82 for filtering air. The filter media 81, 82 can be formed of any of the materials described with respect to the water filter element 45 and the air filter element 48, respectively, of the preceding embodiments. For example, in the present embodiment, each filter medium comprises a microporous membrane. Preferably, the first filter medium 81 is hydrophilic while the second filter medium 82 is hydrophobic, although, as in the preceding embodiments, the first filter medium 81 may include one or more hydrophobic regions through which air can pass to prevent the formation of an air lock on the upstream side of the filter medium. The two media 81, 82 can be formed of a single sheet of material which is divided into two regions and which is treated in one of the regions to give the two regions different properties. For example, a hydrophilic microporous medium may be treated with a solution to make a region hydrophobic. The hydrophilic region will then form the first filter medium 81 for water and the hydrophobic region will form the second filter medium 82 for air. Alternatively, the first and second media 81, 82 may be formed from different sheets of material.

The filter element 80 includes a sealing ring 83 which is sealed to the two filter media 81, 82 in a suitable manner, such as by any of the ways described with respect to the preceding embodiments. In the present embodiment, the sealing ring 83 is mounted on a downstream side of the media but may instead be mounted on the upstream side. The sealing ring 83 has an annular portion extending around the outside of the filter element 80, and it also has a rib 84 which extends between two edges of the ring 83 and separates the downstream surfaces of the two filter media from each other. In this embodiment, both filter media 81, 82 are semicircles of equal area, so the rib 84 extends linearly along a diameter of the sealing ring 83, but the two filter media need not be of the same area or the same shape, and the shape of the rib 84 can be varied in accordance with the desired shape and size of the two filter media.

The opposing ends of the first and second sections 52, 60 of the handle 51 are shaped so that when joined to each other, each section is pressed into sealing contact with one of the surfaces of the filter element 80 (contacting either a surface of the

sealing ring 83 or a surface of the filter media 81, 82) in the vicinity of the outer edge of the annular portion of the sealing ring 83 around its entire circumference and along the rib 84 to isolate water and air flowing through the filter element 80 from each other and to prevent water and air from leaking to the exterior of the handle 51. For example, in the present embodiment, the end surface of the first section 52 of the handle 51 has two semi-circular recesses 53, 55 surrounded by an annular ledge 57 and separated from each other by a diametrically extending rib 58. The upper surface of the ledge 57 is surrounded by an annular wall 59 having an inner diameter somewhat larger than the outer diameter of the filter element 80. A passage for water 54 opens onto the bottom of one recess 53 and a passage for air 56 opens onto the bottom of the other recess 55. When the filter element 80 is installed in the handle 51, it sits on the ledge 57 with the rib 84 of the sealing ring 83 of the filter element 80 aligned with the rib 58 of the first section 52 of the handle 51. The filter element 80 and one or both sections of the handle 51 may be equipped with structure for ensuring that the two ribs 58, 84 are aligned with each other, such as a tab formed in one of the sealing ring 83 and the annular wall 59 and a recess formed in the other of the sealing ring and the annular wall which can receive the tab when the two ribs 58, 84 are aligned with each other. The lower end of the second section 60 of the handle 51 includes unillustrated surfaces which seal against the downstream side of the filter element 80 in the vicinity of the outer edge of the annular portion of the sealing ring 83 around its entire circumference and along the rib 84 of the sealing ring 83. For example, the second section 60 may include an annular ridge having an outer diameter somewhat smaller than the annular wall 59 of the first section 52 and a radial rib extending diametrically between opposite sides of the annular ridge. When the first section 52 of the handle 51 is joined to the second section 60, the annular ridge of the second section 60 is pressed into sealing contact with the downstream surface of the filter element 80 in the vicinity of its outer edge around its entire circumference, and the rib is pressed into sealing contact with the downstream surface of the filter element 80 in alignment with the rib 84 of the filter element 80. The two sections 52, 60 of the handle 51 may be secured to each other in any of the ways described with respect to the preceding embodiments, such as by a hinge or by a nut.

A single replaceable filter element having a filter medium for filtering water and a separate filter medium for filtering air such as shown in Figure 5 is convenient

because it is easy to install and replace in a handle of a dental instrument. In addition, it makes efficient use of the interior space within the handle of the dental instrument and enables the filter media to have a large surface area.

In the embodiments of Figures 1 - 5, a handle for a dental syringe has two sections, and any filter elements are disposed only between the two sections. However, a handle for a dental instrument may have more than two sections, and one or more filter elements can be disposed between each pair of adjoining sections. For example, if a handle has three sections, a filter element for water can be installed between first and second sections of a handle, with a passage for air bypassing the water filter element between the first and second sections, and a filter element for air can be installed between the second section and a third section of the handle, with a passage for water bypassing the air filter element between the second and third sections. In this manner, each filter element may have a larger surface area than if all filter elements are installed at the same location between two adjoining sections of a handle.

As stated above, although Figures 1- 5 illustrate filter elements being installed in the handle of a dental instrument, similar filter elements can be used with any other type of dental instrument having a handle capable of being divided into sections.

Figures 6 - 9 illustrate a dental syringe 100 equipped with another embodiment of a filter 110 according to the present invention. Figure 6 is a cutaway isometric view of the syringe 100 and the filter 110 in an assembled state, while Figures 7-9 are cutaway exploded views of the same. The syringe 100, which may be of conventional structure, includes a handle 101 which can be connected to unillustrated water and air lines, a valve head 102 including buttons 103 for operating unillustrated internal valves of the valve head 102, and a syringe tip 140 capable of being mounted in an outlet opening 104 of the valve head 102 and having one or more fluid outlets 141 for water or air at its distal end. The filter 110 is in the form of an assembly including a housing having an inlet and an outlet, and a filter element 130 disposed inside the housing on a fluid flow path between the inlet and the outlet. The inlet of the filter housing is preferably shaped so as to be capable of being sealingly connected to the valve head 102 of a conventional dental syringe where a syringe tip would normally be mounted, and the outlet is preferably shaped to support and sealingly engage with a conventional syringe tip 140.

The filter housing may have any structure which enables it to support the filter element 130 on a flow path between the valve head 102 of the syringe 100 and the syringe tip 140. Although the housing may be permanently sealed shut, preferably it is capable of being repeatedly opened and closed to enable the filter element 130 to be replaced while permitting the housing to be reused. The illustrated housing includes a first or upstream section 111 which includes an inlet through which fluid can be introduced into the housing and a second or downstream section 120 which includes an outlet through which fluid can be discharged from the housing into a syringe tip 140 and which can be detachably secured to the first section 111. As shown in Figures 6 and 7, the first section 111 includes an inlet nipple 112 which can be inserted into and sealed to a standard opening 104 in the valve head 102 of the syringe 100. One or more sealing members, such as an O-ring 118, may be mounted on the nipple 112 to form a seal against the valve head 102. A passage for water 113 and a passage for air 114 are formed from the nipple 112 to an inner face of the first section 111 which opposes the second section 120. The opening 104 in the valve head 102 typically has a centrally located water outlet 105 and an air outlet 106 formed in its inner surface radially outwards from the water outlet 105. Water and air are supplied to the water and air outlets 105 and 106, respectively, through corresponding passages within the valve head 102. The nipple 112 may have any structure which can fluidly connect the passage for water 113 and the passage for air 114 in the first section 111 of the housing to the water outlet 105 and the air outlet 106, respectively, when the nipple 112 is inserted into the opening 104 in the valve head 102. In the present embodiment, when the nipple 112 is screwed into the opening 104 in the valve head 102, the O-ring 118 which is mounted on the nipple 112 surrounding the upstream end of the water passage 113 is compressed between the end surface of the nipple 112 and the bottom surface of the opening 104 surrounding the water outlet 105, thereby forming a water-tight seal between the two surfaces which prevents water from entering the air passage 114. The opposing surfaces of the nipple 112 and the bottom of the opening 104 are separated by a gap through which air can flow between the air outlet 106 and the air passage 114. An additional sealing member may be provided in a suitable location, such as on the exterior of the nipple 112 outside the opening 104 in the valve head 102, to prevent the leakage of air from the air outlet 106 to the exterior of the valve head 102.

The inner face 115 of the first section 111 functions as a support surface for the filter element 130 and is surrounded by an annular wall 116 which centers the filter element 130 with respect to the inner face. The water passage 113 communicates with a region of the inner face 115 inside the wall 116, while the air passage 114 communicates with a region of the first section 111 located radially outwards from the filter element 130, such as outside the wall 116. In the present embodiment, the downstream end of the water passage 113 where it opens onto the inner face 115 has a hexagonal inner periphery to enable a hex wrench to be inserted into the water passage 113, by means of which the first section 111 can be rotated to attach it to or detach it from the valve head 102 of the syringe 100.

The second section 120 likewise includes a passage for water 122 and a passage for air 123 leading from an inner face of the second section 120 to the outlet 121. The inner face includes a recess 124 in fluid communication with the downstream side of the filter element 130 and an annular sealing ridge 125 surrounding and raised above the recess 124 for sealing against the periphery of the filter element 130. The recess 124 may include one or more support members for providing support to the downstream surface of the filter element 130 while permitting filtrate to readily flow to the water passage 122. In the present embodiment, the second section 120 includes support members in the form of a plurality of ribs 126 which extend radially from the annular sealing ridge 125 towards the axial center of the second section 120 where the water passage 122 is located. The filter element 130 can be pressed against the ribs 126 by fluid pressure without the filter element 130 blocking flow of filtrate to the water passage 122. Another example of a suitable support member is a grid or mesh, either removable or secured to the second section 120 and disposed on the downstream side of the filter element 130.

The filter housing can be made of any suitable material, including both polymers and metals, depending upon the desired strength, corrosion resistance, ability to be autoclaved, costs, or other design considerations.

The filter element 130 is similar in structure to the water filter element 45 illustrated in Figure 4 and includes a filter medium 131 and a sealing ring 132 sealed to the filter medium 131 and extending around the periphery of the filter element 130 so as to surround the region of the filter medium 131 through which fluid passes

during filtration. The filter medium 131 may be made of the same materials described with respect to the water filter element 45 of Figure 4, and the filter element 130 may be formed in the same manner as filter element 45. Like the water filter element 45 of the embodiment of Figure 1, filter element 130 may include a hydrophilic region through which water can pass and a hydrophobic region which prevents the passage of water but permits the passage of air to prevent the formation of a vapor lock on the upstream side of the filter element 130. When the filter housing is closed, the sealing ring 132 of the filter element 130 is sandwiched between the inner face 115 of the first section 111 and the annular sealing ridge 125 of the second section 120, with the ribs 126 of the second section 120 contacting or in close proximity to the downstream surface of the filter medium 131. The upstream surface of the sealing ring 132 is pressed into sealing contact with the inner face 115 of the first section 111 around its entire periphery, while the downstream surface of the filter medium 131 is in sealing contact with the sealing ridge 125 in the vicinity of the peripheral edge of the filter medium 131 around its entire circumference. The downstream end of air passage 114 and the upstream end of air passage 123 are located outside the region surrounded by the sealing ring 132 of the filter element 130, so the sealing ring 132 isolates air flowing through the air passages 114, 123 from water flowing through the water passages 113, 122. Although the illustrated filter element 130 is formed with the sealing ring 132 disposed on the upstream side of the filter medium 131, it is possible to form the filter element 130 so that the sealing ring 132 is disposed on the downstream side of the filter medium 131. A sealing member such as an O-ring 135 may be disposed between the two sections 111 and 120 to prevent the air from the air passages 114, 123 from leaking to the outside of the housing, or the housing sections may be shaped so as to directly seal against each other. However, as the air flowing through the air passages 114, 123 is typically clean, leakage of the air into the environment poses no health hazard, so an air-tight seal between the housing sections is not required.

The two housing sections 111 and 120 can be detachably connected to each other to enclose the filter element 130 in any suitable manner, such as by threaded engagement, a bayonet fit, a snap fit, or using a connector such as a band clamp. In the present embodiment, the first section 111 has two diametrically opposed pins 119 extending from its outer surface, and the second section 120 is formed with two

circumferentially extending slots 127 having one end which communicates with the end surface of the second section 120 and another end which is blind. Upon insertion of the two pins 119 into the corresponding slots 127, the second section 120 is twisted about its axis until the pins 119 move to the blind ends of the slots 127, thereby detachably securing the two sections 111 and 120 to each other.

In order to make the filter element 130 easier to install and replace, the sealing ring 132 of the filter element 130 may be equipped with an integral tab by which the filter element 130 can be grasped. One or both of the sections 111 and 120 of the housing may be formed with a recess for receiving the tab. For example, a recess for the tab can be formed in the annular wall 116 of the first section 111. As described above with respect to the filter element 45 of Figure 4, the sealing ring 132 may also be formed with a plurality of tabs or other engaging portions of different sizes or shapes, and corresponding recesses of different sizes or shapes for receiving the tabs may be formed in one or both of the sections 111 and 120 to ensure that the filter element 130 is installed with a specific orientation with respect to the fluid being filtered.

The outlet 121 of the second section 120 of the housing is shaped so that a syringe tip 140 of conventional design can be detachably mounted on it with the internal water and air passages of the syringe tip 140 in fluid communication with the water and air passages 122 and 123 of the second section 120 of the housing. Many styles of syringe tips are commercially available and employ various ways of connecting the syringe tips to other members, and the outlet 121 can be designed for use with any desired type of syringe tip. Some examples of ways of connecting a syringe tip to a valve head are a threaded connection, a quick-change connection in which a syringe tip is simply pushed into or pulled out of a valve head, and a latched connection in which a syringe tip is released from a valve head when a button is pressed. The illustrated syringe tip 140 is a conventional syringe tip which sealingly engages a commercially available, externally threaded adapter 142 having a centrally located water inlet 143 and an air inlet (not visible in the drawings) which is located radially outwards of the water inlet 143, such as on the outer peripheral surface of the adapter 142. The water inlet 143 communicates with a central water passage within the syringe tip 140, and the air inlet communicates with one or more air passages within the syringe tip 140. The syringe tip 140 can be detachably secured to the

adapter 142 by a standard tip holding nut 144 which screws onto the adapter 142. When the tip holding nut 144 is unscrewed from external threads on the adapter 142, the syringe tip 140 can be disconnected from the adapter 142 to enable the syringe tip 140 to be autoclaved or replaced.

The outlet 121 of the second section 120 of the housing is formed with internal threads for engagement with the external threads on the adapter 142. The downstream end of the water passage 122 of the second section 120 opens onto the center of the bottom surface of the outlet 121, while the downstream end of the air passage 123 opens onto the interior of the outlet 121 radially outwards of the water passage 122. When the adapter 142 is screwed into the outlet 121, the adapter 142 engages the interior of the outlet 121 in substantially the same way that the nipple 112 of the first section 111 of the housing engages the interior of the opening 104 of the valve head 102 so that the water passage 122 will be in fluid communication with the water inlet 143 of the adapter 142 and the air passage 123 will be in fluid communication with the air inlet of the adapter 142 while being fluidly isolated from the water passage 122 and the water inlet 143. The adapter 142 is typically equipped with a sealing ring which surrounds its water inlet 143 and which is compressed between the end surface of the adapter 142 and the bottom surface of the outlet 121 when the adapter 142 is screwed into the outlet 121 so as to form a seal between the two surfaces surrounding the downstream end of the water passage 122 and the water inlet 143 of the adapter 142. At the same time, a gap is present between a portion of the exterior surface of the adapter 142 and a portion of the interior surface of the outlet 121 to enable air to flow from the downstream end of the air passage 123 into the air inlet of the adapter 142. The adapter 142 may also be equipped with an O-ring or other sealing member for forming a seal between the adapter 142 and the second section of the housing to prevent air from leaking to the outside of the housing by flowing between the inner surface of the outlet 121 and the outer surface of the adapter 142.

In the present embodiment, the filter housing is directly connected to the valve head 102. However, it is also possible for an intermediate member, such as an adapter, to be disposed between the housing and the valve head 102. By the use of differently shaped adapters, a single filter housing can be connected to various valve heads designed for different styles of syringe tips.

Because the filter 110 is installed downstream of the valve head 102 and because the syringe tip 140 is replaced or sterilized at frequent intervals, there is no biofilm present downstream of the filter 110, so no bacteria or other contaminants can be introduced into fluid which has passed through the filter 110. The syringe 100 with the filter 110 attached to it is only slightly larger than the same syringe 100 without the filter 110, so the filter 110 does not interfere with the operation of the syringe 100. As the filter element 130 can be replaced without it being necessary to replace the filter housing and because the filter 110 can be mounted on a standard syringe without modification to the syringe, the filter 110 is very economical to use.

A filter having a removable filter element can be employed in locations other than that shown in Figures 6 - 9. For example, instead of being located between a valve head 102 and the upstream end of a syringe tip 140, a filter can be located on the downstream end of a syringe tip 140 or at a location upstream of the valve head 102. A filter according to the present invention can also be employed with dental instruments other than dental syringes. Figure 10 is an isometric view of a high-speed handpiece 200 equipped with another embodiment of a filter 220 according to the present invention, Figure 11 is an exploded isometric view of the filter 220 of Figure 10, and Figure 12 is a cutaway exploded isometric view of the filter 220. The illustrated handpiece 200 is of conventional structure and includes a shaft 201 which is grasped by a user, a head 202 located at one end of the shaft 201 on which a rotary tool 203, such as a drill bit, can be mounted, and a fluid outlet 204 disposed near the tool 203 for dispensing water, air, or other fluids into a patient's mouth during operation of the tool 203. The handpiece 200 is connected to tubing 210 which contains a plurality of internal passages for fluid, cables, or wires. The tubing 210 will typically include a passage for water to be supplied to the fluid outlet 204 of the handpiece 200 and a drive air passage which supplies compressed air for powering a pneumatic rotary drive assembly in the head 202 for rotating the tool 203. It may also include a passage for exhaust air from the drive assembly, a cooling air passage, and a passage for an optical cable. The filter 220 is in the form of an assembly including a housing and a filter element 240 removably installed in the housing. The housing has two sections 221 and 230 which can be detachably connected to each other to enclose the filter element 240. The filter element 240, which may have any desired structure but which is illustrated as being similar in structure to the water

filter elements 45 and 130 of the preceding embodiments, includes a filter medium 241 capable of removing undesired substances (preferably including microorganisms and endotoxins or other pyrogens) from water and a sealing ring 242 sealed to the filter medium 241. The first housing section 221 includes an inlet 222 which can be connected to the water passage in the tubing 210 so as to receive water to be filtered, and the second housing section 230 includes an outlet 231 which can also be connected to the water passage to return filtered water to the tubing 210. The filter 220 is connected in series with one of the fluid passages (such as a passage for water or a passage for air) such that all fluid flowing through the passage will pass through the filter 220 and undergo filtration. For example, when the tubing 210 comprises extruded plastic tubing, it can be cut to remove a section of the water passage of the tubing 210 to form two open ends in the passage without cutting into the other fluid passages of the tubing 210. The inlet 222 and outlet 231 can then be connected to the open ends of the water passage in any suitable manner, such as by inserting the inlet 222 into one of the open ends and inserting the outlet 231 into the other open end. The inlet 222 and outlet 231 may be equipped with hose barbs or other suitable structures to increase the tightness of their connection to the ends of the water passage. The inlet 222, the outlet 231, and the ends of the water passage may also be equipped with quick release connectors, such as Luer fittings or threaded couplings, to enable the filter 220 to be quickly replaced. Alternatively, the inlet 222 and outlet 231 may be permanently connected to the water passage by bonding, for example.

At its end remote from the inlet 222, the first section 221 of the housing includes a recess 225 surrounded by an annular ledge 226 for supporting a filter element. An internal passage 227 for water or other fluid to be filtered communicates between the inlet 222 and the recess 225. At its end remote from the outlet 231, the second section 230 also includes a recess 233 surrounded by an annular sealing ridge 234 projecting above the recess 233. When the filter element 240 is placed between the first and second sections 221 and 230 and the sections are combined with each other, the sealing ring 242 of the filter element is sandwiched between and sealed against the ledge 226 of the first section 221 and the sealing ridge 234 of the second section 230. One or more support members 236, such as radially extending ribs or a removable grid or plate, are disposed in the recess 233 of the second section 230 for supporting the downstream surface of the filter medium 241. A water passage 235

for water or other fluid which has been filtered by the filter element 240 communicates between the recess 233 in the second section 230 and the outlet 231. The support members 236 enable fluid which has passed through the filter element 240 to readily drain from the recess 233 into the water passage 235. When the filter element 240 is installed in the housing, the support members 236 contact or are in close proximity to the downstream surface of the filter medium 241 of the filter element 240.

The first and second housing sections 221 and 230 may be equipped with structure for detachably securing them to each other. In the present embodiment, as in the embodiment of Figures 6 - 9, the housing sections 221 and 230 secured to each other by pins 228 formed on the first section 221 and circumferentially extending slots 237 formed on the second section 230 for engagement with the pins 228. With such a structure, the two sections 221 and 230 can be secured to or disconnected from each other simply by twisting the sections with respect to each other.

A filter for connection in a fluid line on the upstream side of a dental instrument is not limited to use with any particular type of dental instrument. Furthermore, while a single filter is shown in Figures 6 - 9, a dental instrument can be equipped with a plurality of similar filter assemblies for connection to corresponding fluid lines for the dental instrument. For example, if the dental instrument is of the type which supplies both water and air to a patient's mouth, a separate filter can be provided for a water line and for an air line of the dental instrument.

Figures 13 - 15 illustrate another embodiment of a filter 260 according to the present invention which can be connected between a dental instrument and tubing 250 for supplying one or more fluids to the dental instrument. These figures show the filter 260 connected to a conventional high-speed handpiece 200 like that shown in Figure 10, but the filter 260 can also be used with syringes, sonic and ultrasonic scalers, or other types of dental instruments by which fluids are dispensed into a patient's mouth. The filter 260 is in the form of an assembly including a housing comprising a body 270 and a cover 290 which can be detachably mounted on the body 270, and a filter element 300 which can be disposed in the housing between the body 270 and the cover 290 along a flow path for a fluid to be filtered extending from the tubing 250 to the handpiece 200. The illustrated body 270 has three arms

271 - 273. The first arm 271 is adapted to be connected to the downstream end of standard tubing 250 for use with the handpiece 200, the second arm 272 is adapted to be connected to the proximal end of the handpiece 200, and the third arm 273 is adapted to be connected to the cover 290. In the present embodiment, the body 270 is substantially T-shaped with the first and second arms 271 and 272 aligned with each other and with the third arm 273 extending at right angles to the first two arms 271, 272. Such a shape is convenient when the user of the handpiece 200 wishes to have the tubing 250 extend coaxially with the handle 201 of the handpiece 200, but the body 270 may have any other shape which enables it to be connected to the handpiece 200, the tubing 250, and the cover 290. The body 270 is shown with the third arm 273 extending vertically, but it may be made to extend in any direction that is convenient for the user.

The body 270 includes a plurality of internal passages through which fluids, wires, optical cables, or other members or substances can pass from the tubing 250 to the handpiece 200. The number of passages will depend upon the type of handpiece 200 or other dental instrument with which the filter 260 is to be used. The illustrated body 270 includes a drive air passage 274 which carries drive air used to drive the rotor of the handpiece 200, an exhaust air passage (hidden behind the passage for drive air 274 in the drawings) for carrying exhaust air discharged from the rotor, a passage 275 through which a fiberoptic cable can pass to provide illumination at the distal end of the handpiece 200 (the end where the rotary tool 203 is mounted), a spray air passage (not visible in the drawings) for carrying air which is to be sprayed into a dental patient's mouth, and first and second passages 276 and 277 for water or other fluid which is to be dispensed into the dental patient's mouth after being filtered. The first passage for water 276 extends from the outer end of the first arm 271 to the outer end of the third arm 273 to introduce water to be filtered to the upstream side of the filter element 300. The second passage for water 277 extends from the outer end of the third arm 273 to the outer end of the second arm 272 to supply filtered water which has passed through the filter element 300 to the handpiece 200. The passages other than the passages for water 276 and 277 extend directly between the outer end of the first arm 271 and the outer end of the second arm 272 and therefore bypass the filter element 300. At the outer end of the first arm 271, each of the passages is equipped with a fitting 278 of standard dimensions for

engagement with a standard unillustrated connector attached to the end of the tubing 250. Similarly, at the outer end of the second arm 272, each of the passages is shaped for engagement with a corresponding fitting 205 of a standard connector mounted on the proximal end of the handpiece 200 (the end remote from the rotary tool 203). The tubing 250 is equipped with a retaining nut 251 which is rotatably mounted on the end of the tubing 250 and which has internal threads which are sized for engagement with external threads 206 on the proximal end of the handpiece 200. The outer end of the first arm 271 is formed with similar external threads 282 which can engage with the internal threads of the retaining nut 251 on the tubing 250 so that the first arm 271 can be detachably secured to the tubing 250. The outer end of the second arm 272 is equipped with a retaining nut 283 similar to the retaining nut 251 of the tubing 250 to enable the second arm 272 to be detachably secured to the proximal end of the handpiece 200. The retaining nut 283 is rotatably mounted on the exterior of the second arm 272 and is prevented from being detached from the second arm 272 by a retaining member, such as a collar 284 which is press fit on the second arm 272 inside the retaining nut 283 and which resists axial movement of the retaining nut 283 in a direction away from the body 270 while permitting the retaining nut 283 to rotate. The retaining nut 283 is formed with internal threads which can engage with the external threads 206 on the proximal end of the handpiece 200. This arrangement enables the body 270 to be easily connected to standard tubing 250 and a standard handpiece 200. However, many other arrangements can be employed to secure the body 270 to the tubing 250 or the handpiece 200, such as a snap fit or a clamp.

The outer end of the third arm 273 is formed with a recess 285 surrounded by a ledge 286 for contacting the outer periphery of the filter element 300. The ledge 286 is surrounded by an annular wall 287 which surrounds the filter element 300 when the filter element 300 is mounted on the ledge 286. The first water passage 276 opens onto the end surface of the outer wall 287, while the second water passage 277 opens onto the bottom of the recess 285. The recess 285 may contain structure for supporting the downstream surface of the filter medium 301 against fluid pressures tending to force the filter medium 301 into the recess 285, such as ribs like the radial support ribs 236 of the second housing section 230 shown in Figure 11, a perforated plate, a mesh layer, or other member capable of contacting the

downstream surface of the filter medium 301 to support it while providing drainage of filtrate to the second water passage 277. In the present embodiment, a support member in the form of a perforated plate 305 is removably disposed in the recess 285 on the downstream side of the filter element 300.

The cover 290 includes an annular ridge 291 which projects upwards from the bottom inner surface of the cover 290. The ridge 291 has a diameter such that when the cover 290 is mounted on the third arm 273 of the body 270 with the filter element 300 disposed between the body 270 and the cover 290, the filter element 300 will be sandwiched between the ledge 286 of the body 270 and the ridge 291 of the cover 290 with one surface of the filter element 300 in sealing contact with the ledge 286 around the entire circumference of the filter element 300 and the opposite surface of the filter element 300 in sealing contact with the ridge 291 around the entire circumference of the filter element 300.

The cover 290 is equipped with internal threads which can engage with external threads formed on the third arm 273 to enable the cover 290 to be detachably secured to the third arm 273. Many other arrangements can be employed to secure the cover 290 and the third arm 273 to each other, such as a bayonet fit, a snap fit, or a clamp. A sealing member, such as an O-ring 295, may be provided in a suitable location, such as in a groove on the exterior of the third arm 273, to form a fluid-tight seal between the cover 290 and the third arm 273 in a region surrounding the filter element 300.

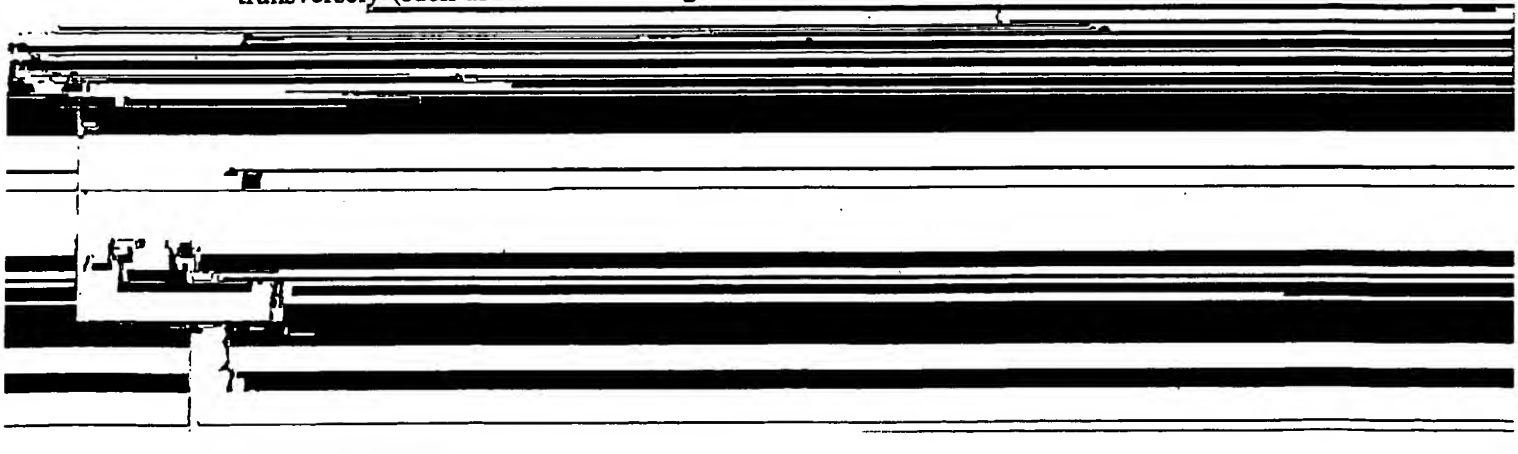
As shown in Figure 15, when the cover 290 is mounted on the third arm 273, a space 294 communicating with the downstream end of the first water passage 276 is formed between the cover 290 and the third arm 273. The annular ridge 291 is formed with one or more openings 292 which extend through the ridge 291 between its inner and outer peripheries to provide fluid communication between the space and a region surrounded by the ridge 291 on the upstream side of the filter element 300. The openings 292 are spaced from the portion of the ridge 291 which contacts the filter element 300 so as not to interfere with the seal between the ridge 291 and the filter element 300.

The filter element 300 may have any structure which enables it to remove desired substances from the water passing through the water passages 276, 277. In the illustrated embodiment, the filter element 300 is similar in structure to the filter

element 240 of the embodiment of Figures 10 - 12, including a disc-shaped filter medium 301 and a sealing ring 302 bonded to one surface of the filter medium 301. Like the sealing ring 242 of filter element 240, the sealing ring 302 may be formed with one or more tabs by which the filter element 300 can be grasped or which can be used to orient the filter element 300, in which case one or more notches 288 for receiving the tab(s) may be formed in the outer wall 287 of the third arm 273. The filter medium 301 may be made of any of the materials and have any of the properties of the filter media described with respect to the previous embodiments. The illustrated filter element 300 is formed with the sealing ring 302 disposed on the downstream side of the filter medium 301, but it is instead possible to form the filter element 300 so that the sealing ring 302 is on the upstream side of the filter medium 301, or so that sealing rings are provided on both the upstream and downstream sides.

Having a filter connected to the proximal end of a dental instrument as in the present embodiment is advantageous because it enables the filter to be used with a larger variety of dental instruments than if the filter is mounted on the distal end. Furthermore, the filter does not change the length or weight of equipment outboard of the hand of the user, so the user feels very little difference between using a dental instrument with a filter according to the present invention and using a dental instrument without a filter, and the user can quickly adapt to the presence of the filter on the dental instrument. In addition, there are fewer restraints on the size of a filter when it is located on the proximal end of a dental instrument, so the filter may be easier to manufacture and the filter element may have a larger surface area.

Figures 16 and 17 are respectively an isometric view and an exploded longitudinal cross-sectional view of another embodiment of a filter according to the present invention installed on a high-speed handpiece 200. This embodiment is substantially the same as the embodiment of Figures 13 - 15 except that the third arm 273 of the body 270 is coaxial with the second arm 272 and the first arm 271 extends transversely (such as at an obtuse angle of 120° or any other angle which is



Figures 18 - 23 illustrate another embodiment of a filter according to the present invention for use with a dental instrument. The filter 400 is shown being used with a conventional high-speed handpiece 200, but the filter 400 may also be employed with any other type of dental instrument to which tubing for supplying a fluid to the dental instrument is connected. The illustrated filter 400 is in the form of an assembly including a housing comprising a body 401 which surrounds tubing 250 for supplying fluids to the handpiece 200 and a cover 440 which can be detachably mounted on the body 401. It further includes a filter element 300 which is removably disposed in the housing between the body 401 and the cover 440 along a flow path of a fluid to be filtered. The tubing 250 contains a plurality of fluid passages, one of which, 252, is in fluid communication with the filter element 300, while the other fluid passages within the tubing 250 pass through the filter 400 without interruption.

The body 401 of the housing includes a first section 410 which is shaped to engage with the cover 440 and a second section 430 which can be combined with the first section 410 to define an elongated chamber extending between the lengthwise ends of the body 401 through which the tubing 250 for the handpiece 200 can pass. The two sections 410, 430 of the body 401 can be either detachably or permanently connected to each other. For example, if the body 401 is intended to have the same life span as the tubing 250 with which it is used, the sections 410, 430 of the body 401 may be permanently connected to each other around the tubing 250 by bonding, welding, rivets, or similar means. On the other hand, if the body 401 or the tubing 250 is intended to be replaceable, the sections 410, 430 may be detachably connected to each other by a snap fit, a press fit, removable screws, a hinge, or similar arrangements. In the present embodiment, the sections 410, 430 are detachably connected to each other by unillustrated screws which are inserted into openings 413 in the bottom surface of the first section 410, pass through pillars 414 formed on the upper surface of the first section 410, and screw into threaded holes formed in corresponding pillars on the lower surface of the second section 430 of the body 401.

The upper portion of the first section 410 of the body 401 has an opening 411 at each of its lengthwise ends, and the second section 430 likewise has an opening 431 at each of its lengthwise ends. When the two sections 410, 430 are joined to each other, the tubing 250 can pass through the openings 411, 431. As best shown in Figure 20, which is a bottom plan view of the first section 410 of the body 401, a

recess 418 surrounded by a ledge 420 for sealing contact with the outer periphery of a filter element 300 is formed at the lower end of the first section 410. The ledge 420 is surrounded by an annular wall 421 which surrounds the filter element 300 when the filter element 300 is mounted on the ledge 420. A first passage 415 for a fluid to be filtered extends between the upper side of the first section 410 and an opening 422 in the annular wall 421, and a second passage 416 for filtered fluid which has passed through the filter element 300 extends between the upper side of the first section 410 and the bottom of the recess 418. The recess 418 may contain a support structure capable of supporting the downstream surface of the filter medium of the filter element 300 against fluid pressures tending to urge the filter medium into the recess 418, such as ribs, projections, or a removable plate or grid. In the present embodiment, the recess 418 contains a support structure comprising a plurality of projections 419 extending along arcs of circles, between which filtrate can flow to reach the upstream end of the second fluid passage 416.

The upstream end of the first fluid passage 415 is capable of being connected to one of the fluid passages 252 within the tubing 250, and the downstream end of the second fluid passage 416 is capable of being connected to the same fluid passages 252. The fluid passages 415, 416 in the body 401 may be connected to the fluid passages 252 in the tubing 250 in any suitable manner. In the present embodiment, a hose barb connector 417 is secured to the first section 410 of the body 401 at the upstream end of the first fluid passage 415 and at the downstream of the second fluid passage 416, and a section of one of the fluid passages 252 in the tubing 250 can be detachably or permanently secured to each hose barb connector 417. Many other means can be used to connect the tubing 250 to the first section 410 of the body 401, such as Luer connectors or other type of quick release connectors. Alternatively, connectors may be omitted and the fluid passages 415, 416 may be directly connected to the first section 410 of the body 401 by bonding, for example.

The cover 440 may have any structure which enables it to enclose the filter element 300 along a flow path of fluid to be filtered. The illustrated cover 440 is similar in structure to the cover 190 of the embodiment of Figure 13. It includes an annular ridge 441 which projects upwards from the bottom inner surface of the cover 440 and which has a diameter such that when the cover 440 is mounted on the first section 410 of the body 401 with the filter element 300 disposed between the body

401 and the cover 440, the filter element 300 will be sandwiched between the ledge 420 of the first section 410 of the body 401 and the ridge 441 of the cover 440, with one surface of the filter element 300 in sealing contact with the ledge 420 around the entire periphery of the filter element 300 and with the opposite surface of the filter element 300 in sealing contact with the ridge 441 around the entire periphery of the filter element 300.

Preferably the cover 440 is detachable from the body 401 to enable the filter element 300 to be readily replaced. In the present embodiment, the cover 440 has internal threads 443 which screw onto external threads 424 formed on the body 401, but any other type of detachable engagement between the body 401 and the cover 440 which can maintain the filter element 300 in sealing contact with the body 401 and the cover 440 can be employed, such as a bayonet fit, a snap fit, or a press fit. A sealing member, such as an O-ring 445, may be provided to form a fluid-tight seal between the cover 440 and the body 401 in a region surrounding the filter element 300 and both fluid passages 415, 416.

When the cover 440 is mounted on the body 401, a space 444 communicating with the downstream end of the first fluid passage 415 is formed between the body 401 and the cover 440 around the annular ridge 441. The annular ridge 441 is formed with one or more openings 442, similar to the opening 192 in the embodiment of Figure 13, which extend through the ridge 441 between its inner and outer peripheries to provide fluid communication between the space 444 surrounding the ridge 441 and the region surrounded by the ridge 441 on the upstream side of the filter element 300.

The filter element 300 may have any desired structure, such as the same structure as described with respect to any of the preceding embodiments. The illustrated filter element 300 is similar to the filter element 200 of the embodiment of Figure 14 and includes a disc-shaped filter medium 301 and a sealing ring 302 bonded to the downstream surface of the filter medium 301, although it may instead be bonded to the upstream surface. The sealing ring 302 includes two radially outward tabs 303 of different sizes, and the annular wall 421 includes two notches 423 having different lengths in the circumferential direction of the wall 421. One of the tabs 303 has a length in the circumferential direction small enough for it to fit into the smaller notch 423 in the annular wall 421, while the other tab 303 has a

circumferential length such that it can only fit into the larger notch 423.

In order to make the filter 400 easier to use, the body 401 is preferably restrained against movement, such as translation or rotation, with respect to the tubing 250. The body 401 itself may fit snugly around the tubing 250 so as to resist movement, or the body 401 may be equipped with separate members which resist movement of the body 401. In the present embodiment, the body 401 is equipped with two clamping members 450 which fit snugly around the tubing 250 and are clamped between the first and second sections 410, 430 of the body 401 to prevent movement of the clamping members 450 with respect to the body 401. Each clamping member 450 is formed of a generally semicircular upper section 451 and a generally semicircular lower section 452 which can be detachably engaged with each other to define a ring having an inner peripheral surface which is similar in shape to the outer peripheral surface of the tubing 250 and which can frictionally engage the outer peripheral surface of the tubing 250. The sections 451, 452 may include engaging portions, such as projections on one section and corresponding recesses in the other section, which can engage each other to resist movement of the sections 451, 452 with respect to each other. Each section 451, 452 contains slots 453 which can slidably receive corresponding flanges 412 and 432, respectively, of the body sections 410, 430 when each section 451, 452 of the clamping member 450 is inserted into the corresponding body section. When the flanges 412, 432 enter the slots 453, the sections 451, 452 of the clamping member 450 are prevented from movement in the lengthwise direction of the body 401.

The filter 400 can be connected to a length of tubing 250 by carefully cutting into the tubing 250 to form two open ends in one of the fluid passages 252 in the tubing 250 without cutting into the other fluid passages. Each open end is then connected to one of the fluid passages 415, 416 in the first section 410 of the body 401 in a manner such that fluid can flow between the interior of the fluid passage 252 and the interior of the first section 410 of the body 401 without leaking. The body 401 can then be assembled around the tubing 250 by inserting the lower sections 452 of the clamping members 450 into the first section 410 of the body 401 and then placing the tubing 250 atop the first section 410 of the body 401 and the lower sections 452 of the clamping members 450 as shown in Figure 21. The upper sections 451 of the clamping members 450 are then placed atop the lower sections

452 of the clamping members 450 and the tubing 250, and the second section 430 of the body 401 is placed atop the upper sections 451 of the clamping members 450 and is secured to the first section 410 of the body 401 by screws or other suitable securing members. In an assembled state, the body 401 appears as shown in Figure 18. In this state, the ends of the tubing 250 can be connected to a dental instrument and a source of fluids for the dental instrument in a conventional manner. The filter 400 can be easily installed on tubing 250 by the operator of the dental instrument, or it can be installed on tubing 250 in advance at a factory and sold to the customer together with the tubing 250 as an assembly ready for connection to a dental instrument.

Instead of being separate members, the clamping members 450 may be integrally formed with or permanently secured to the body sections 410, 430. However, it is convenient if the clamping members 450 are detachable from the body sections 410, 430 so that a single body 401 can be used with tubing 250 of different sizes or shapes simply by replacing the clamping members 450 with ones of a different size or shape. For example, since tubing for use with a dental syringe is typically smaller than tubing for use with a high-speed handpiece (tubing for a dental syringe frequently has two fluid passages, while tubing for a high-speed handpiece usually has three or more fluid passages), one set of clamping members can be employed when the tubing 250 is for a dental syringe, and a different set of clamping members with the same external dimensions but with a larger opening through which tubing can pass can be employed when the tubing 250 is for a handpiece.

The portion of the fluid passage 252 that extends from the first section 410 of the body 401 to the handpiece 200 or other dental instrument may be part of the same tubing 250 that passes through the body 401. However, it may simplify connection of the filter 400 to tubing 250 to use a fluid passage formed separately from the tubing 250, such as a simple hose of suitable diameter. In this case, the portion of the fluid passage 252 of the original tubing 250 extending from the body 401 to the dental instrument can be removed, and the separately formed fluid line can be inserted into the cavity in the original tubing 250 left by removal of the portion of the fluid passage 252.

The tubing 250 shown in Figure 18 has a single filter 400 mounted on it, but it may instead have a plurality of filters of the type shown in Figures 18 - 23 disposed

along its length at different locations. For example, a filter for water can be installed at one location and a filter for air at another location. Alternatively, a plurality of filters containing the same of different types of filter elements for the same fluid passage 252 in the tubing 250 may be installed in series at different locations along the tubing 250.

Having a filter surrounding tubing 250 in the manner shown in Figures 18 - 23 helps maintain a reliable connection between the tubing 250 and the filter 400 because the weight of the filter 400 is supported by the entire tubing 250 rather than just by a single fluid passage of the tubing 250. Furthermore, since the filter 400 can be snugly clamped to the tubing 250, the filter 400 does not interfere with the use of the tubing 250, and it is less likely to catch on objects than if the filter were dangling loosely from the tubing 250.

Although the present invention has been described with respect to a number of preferred embodiments, the present invention is not limited to these embodiments, and one or more features of one embodiment may be freely combined with one or more features of other embodiment or embodiments while remaining within the scope of the present invention.

What is claimed is:

1. An arrangement for use in dental procedures comprising:

a dental instrument including a handle with first and second sections each having a passage for fluid, and an outlet for dispensing fluid into a patient's mouth communicating with the passages for fluid; and

a filter medium disposed between the two sections in a flow path connecting the passages for fluid.

2. An arrangement as claimed in claim 1 including a sealing ring surrounding a region of the filter medium through which fluid is to pass during filtration and sealed against one of the sections of the handle.

3. An arrangement as claimed in claim 1 including two passages for fluid in each section of the handle and two filter media each disposed between the two sections in a flow path connecting two of the fluid passages.

4. An arrangement as claimed in claim 1 wherein the first and second filter media are part of a single filter element.

5. An arrangement as claimed in claim 1 wherein the first and second sections have opposing surfaces extending non-perpendicular to an axis of the handle.

6. An arrangement as claimed in claim 1 wherein the first and second sections of the handle are hinged to each other.

7. An arrangement as claimed in claim 1 wherein the first and second sections are movable in an axial direction of the handle between an open and a closed position.

8. An arrangement as claimed in claim 1 wherein the filter medium comprises a filter membrane.

9. A dental instrument comprising:

a hinged handle including first and second sections which can be pivoted between an open position and a closed position in which a filter medium can be disposed between the two sections, and a passage for fluid formed in each section; and

a fluid outlet for dispensing fluid into a patient's mouth communicating with the passages in the handle.

10. A dental instrument as claimed in claim 9 wherein the dental instrument comprises a dental syringe including a syringe tip having the fluid outlet, and a valve disposed between the handle and the syringe tip for controlling fluid flow into the syringe tip.

11. An arrangement for dental procedures comprising:

a dental syringe including a syringe tip, an internal passage for water, and a valve disposed in series with the passage for water between the passage and the syringe tip; and

a filter disposed in series with the syringe tip between the syringe tip and the passage for water and comprising first and second detachable housing sections and a filter medium removably disposed between the housing sections.

12. An arrangement as claimed in claim 11 wherein the syringe includes a valve head having an opening capable of receiving the syringe tip, and the housing includes an inlet inserted into the opening in the valve head and an outlet engaged with the syringe tip.

13. An arrangement as claimed in claim 11 wherein the housing defines a first fluid flow path passing through the filter medium between the inlet and outlet and a second fluid flow path extending between the inlet and outlet and bypassing the filter medium.

14. An arrangement as claimed in claim 13 including a sealing member contacting the filter medium and forming a seal separating the first and second fluid

flow paths.

15. An arrangement for dental procedures comprising:

a dental instrument having a fluid outlet for dispensing fluid into a mouth of a dental patient; and

a filter medium which is disposed along a fluid path passing through the outlet and which is positively charged in water and capable of removing endotoxins from fluid passing therethrough.

16. An arrangement as claimed in claim 15 wherein the filter medium comprises a microporous membrane.

17. An arrangement as claimed in claim 15 wherein the filter medium is installed within the dental instrument.

18. An arrangement as claimed in claim 15 wherein the filter medium is installed upstream of the dental instrument.

19. An arrangement as claimed in claim 15 wherein the dental instrument includes a valve for controlling fluid flow to the outlet, and the filter medium is installed downstream of the valve.

20. An arrangement as claimed in claim 15 including a filter housing detachably mounted on the dental instrument and containing the filter medium.

21. A filter for use with a dental syringe comprising:

a filter housing including an inlet adapted for mounting on a valve head of a dental syringe, an outlet adapted for detachably receiving a syringe tip for a dental syringe, an air passage communicating within the housing between the inlet and the outlet, and a water passage communicating within the housing between the inlet and the outlet; and

a filter element disposed in the housing along the water passage so as to filter water passing through the water passage between the inlet and the outlet, the

filter element including a sealing ring forming a seal separating the water passage and the air passage.

22. An arrangement for dental procedures comprising:

a dental instrument having an outlet for dispensing water into a patient's mouth; and

a filter medium disposed along a fluid flow path communicating with the outlet for filtering water to be dispensed through the outlet and having a hydrophilic region and a hydrophobic region through which air in water being filtered can pass.

23. An arrangement as claimed in claim 22 wherein the hydrophobic region comprises at most approximately 25% of a total area of the hydrophobic and hydrophilic regions.

24. An arrangement as claimed in claim 22 wherein the hydrophobic region comprises at most approximately 15% of a total area of the hydrophobic and hydrophilic regions.

25. An arrangement as claimed in claim 22 wherein the hydrophobic region comprises approximately 5% to approximately 10% of a total area of the hydrophobic and hydrophilic regions.

26. A filter for use in filtering a fluid to be discharged into a patient's mouth during a dental procedure comprising:

a substantially flat filter medium; and

a sealing ring sealed to the filter medium and extending around a region of the filter medium through which fluid is to pass during filtration.

27. A filter as claimed in claim 26 wherein the sealing ring extends along an outer periphery of the filter.

28. A filter as claimed in claim 26 wherein the sealing ring comprises a flat gasket.

29. A filter as claimed in claim 26 wherein the sealing ring is laminated to the filter medium.

30. A filter as claimed in claim 26 wherein the filter medium comprises a membrane.

31. A filter as claimed in claim 26 wherein the filter medium has first and second opposite surfaces, and the sealing ring is disposed on one of the surfaces.

32. A filter for use in filtering a fluid to be discharged into a patient's mouth during a dental procedure comprising:

a filter medium at least a portion of which is hydrophilic; and

a sealing ring sealed to the filter medium and extending around a region of the filter medium through which fluid is to pass during filtration.

33. A filter for use in filtering a fluid to be discharged into a patient's mouth during a dental procedure comprising:

a filter medium having a hydrophilic region and a hydrophobic region through which air in a fluid being filtered can pass; and

a sealing ring sealed to the filter medium and extending around a region of the filter medium through which fluid is to pass during filtration.

34. A filter for use in filtering a fluid to be discharged into a patient's mouth during a dental procedure comprising:

a filter medium which is positively charged in water and capable of removing endotoxins from fluid passing therethrough; and

a sealing ring sealed to the filter medium and extending around a region of the filter medium through which fluid is to pass during filtration.

35. A filter for use with a dental instrument comprising:

a body having a first portion adapted for connection to tubing for a dental instrument, a second portion adapted for connection to a handle of a dental instrument, a first passage for fluid having a first end in the first portion and a second

end, and a second passage for fluid having a first end in the second portion and a second end;

a cover detachably mounted on the body; and

a filter medium removably disposed between the body and the cover on a flow path connecting the second ends of the first and second passages for fluid.

36. A filter as claimed in claim 35 wherein the body is substantially T-shaped with the first and second portions being coaxial with each other and includes a third portion extending transversely with respect to the first and second portions, and the cover is mounted on an outer end of the third portion.

37. A filter as claimed in claim 35 wherein the second portion is adapted for connection to a dental handpiece, and the body includes a passage for drive air for driving a dental handpiece extending between outer ends of the first and second portions and bypassing the filter medium.

38. A filter as claimed in claim 35 wherein the body includes a passage for a fiberoptic cable extending between outer ends of the first and second portions and bypassing the filter medium.

39. A filter as claimed in claim 35 wherein the first and second portions extend transversely with respect to each other, the body includes a third portion extending coaxially with the second portion, and the cover is mounted on an outer end of the third portion.

40. A filter for use with a dental instrument comprising:

a housing adapted to be installed in a fluid flow path passing through a dental instrument and having an inlet and an outlet and first and second detachable sections; and

a replaceable filter medium for filtering a fluid to be dispensed into a dental patient's mouth via a dental instrument removably disposed in the housing between the first and second sections and between the inlet and outlet.

41. An arrangement for dental procedures comprising:

a dental instrument having an outlet for dispensing a fluid into a dental patient's mouth; and

a filter comprising a housing installed in a fluid flow path for the fluid to be dispensed leading through the dental instrument to the outlet of the dental instrument and having first and second detachable sections, and a replaceable filter medium for filtering the fluid to be dispensed removably disposed in the housing between the first and second sections in the fluid flow path.

42. An arrangement for use with a dental instrument comprising:

tubing including an internal flow passage for supplying a fluid to a dental instrument; and

a filter for filtering the fluid to be supplied to the dental instrument comprising a housing connected in-line with the internal flow passage and having first and second detachable sections, and a replaceable filter medium for filtering the fluid to be supplied removably disposed in the housing between the first and second sections.

43. An arrangement as claimed in claim 42 wherein the tubing passes through the housing.

44. An arrangement for dental procedures comprising:

a dental instrument having an outlet for dispensing a fluid into a dental patient's mouth; and

a filter comprising a housing installed in a fluid flow path leading to the outlet of the dental instrument, and a replaceable filter membrane for filtering the fluid removably disposed in the housing in the fluid flow path.

45. An arrangement as claimed in claim 44 wherein the housing comprises first and second sections and the filter membrane is disposed between the first and second sections.

46. An arrangement as claimed in claim 44 including a sealing ring forming a

seal between the filter membrane and an interior of the housing.

47. A filter for use with a dental instrument comprising:

a housing containing a passage through which tubing for supplying a fluid to a dental instrument can pass, a first fluid passage for a fluid to be filtered, and a second fluid passage for fluid that has been filtered; and

a filter medium disposed in the housing on a flow path between the first and second passages.

48. A filter as claimed in claim 47 wherein the filter is removably disposed in the housing.

49. A filter as claimed in claim 47 including first and second connectors within the housing connected to the first and second fluid passages of the housing for fluidly connecting the fluid passages of the housing to a fluid passage in the tubing.

50. A filter as claimed in claim 47 wherein the housing is adapted to fit snugly around the tubing.

51. A filter as claimed in claim 50 including a clamp for clamping the tubing to the housing.

52. A filter as claimed in claim 51 wherein the clamp is detachable from the housing.

53. A filter as claimed in claim 52 wherein the clamp includes a plurality of sections which can be assembled around the tubing to form a ring.

54. An arrangement for use with a dental instrument comprising:

tubing for supplying a fluid to a dental instrument; and

a filter comprising a housing containing a passage through which the tubing passes, a first fluid passage for a fluid to be filtered fluidly connected to an interior of the tubing, and a second fluid passage for fluid that has been filtered

fluidly connected to the interior of the tubing, and a filter medium disposed in the housing between the first and second fluid passages.

55. A method of using a dental instrument comprising placing a filter membrane along a first path for fluid within a dental instrument and filtering fluid passing through the path.

56. A method as claimed in claim 55 including disposing the filter membrane between adjoining sections of a handle of the dental instrument.

57. A method as claimed in claim 55 including placing a second filter membrane along a second path for fluid within the dental instrument.

58. A method of filtering comprising:

passing a fluid for use in a dental procedure through a filter element comprising a filter medium and a sealing ring extending around a region of the filter medium and sealed to the filter medium; and

discharging the fluid which was passed through the filter element into a dental patient's mouth.

59. A method of filtering comprising:

passing a fluid for use in a dental procedure through a filter medium having a hydrophilic region and a hydrophobic region; and

discharging the fluid passed through the filter medium into a dental patient's mouth.

60. A method of filtering comprising:

passing a fluid for use in a dental procedure through a first filter membrane disposed in a housing;

discharging the fluid which was passed through the first filter membrane into a dental patient's mouth;

removing the first filter membrane from the housing and replacing the first filter membrane in the housing with a second filter membrane; and

passing a fluid for use in a dental procedure through the second filter membrane and discharging it into a dental patient's mouth.

61. A method of filtering comprising:

passing a fluid for use in a dental procedure through a filter medium which is positively charged in water and capable of removing endotoxins from the fluid; and

discharging the fluid passed through the filter medium into a dental patient's mouth.

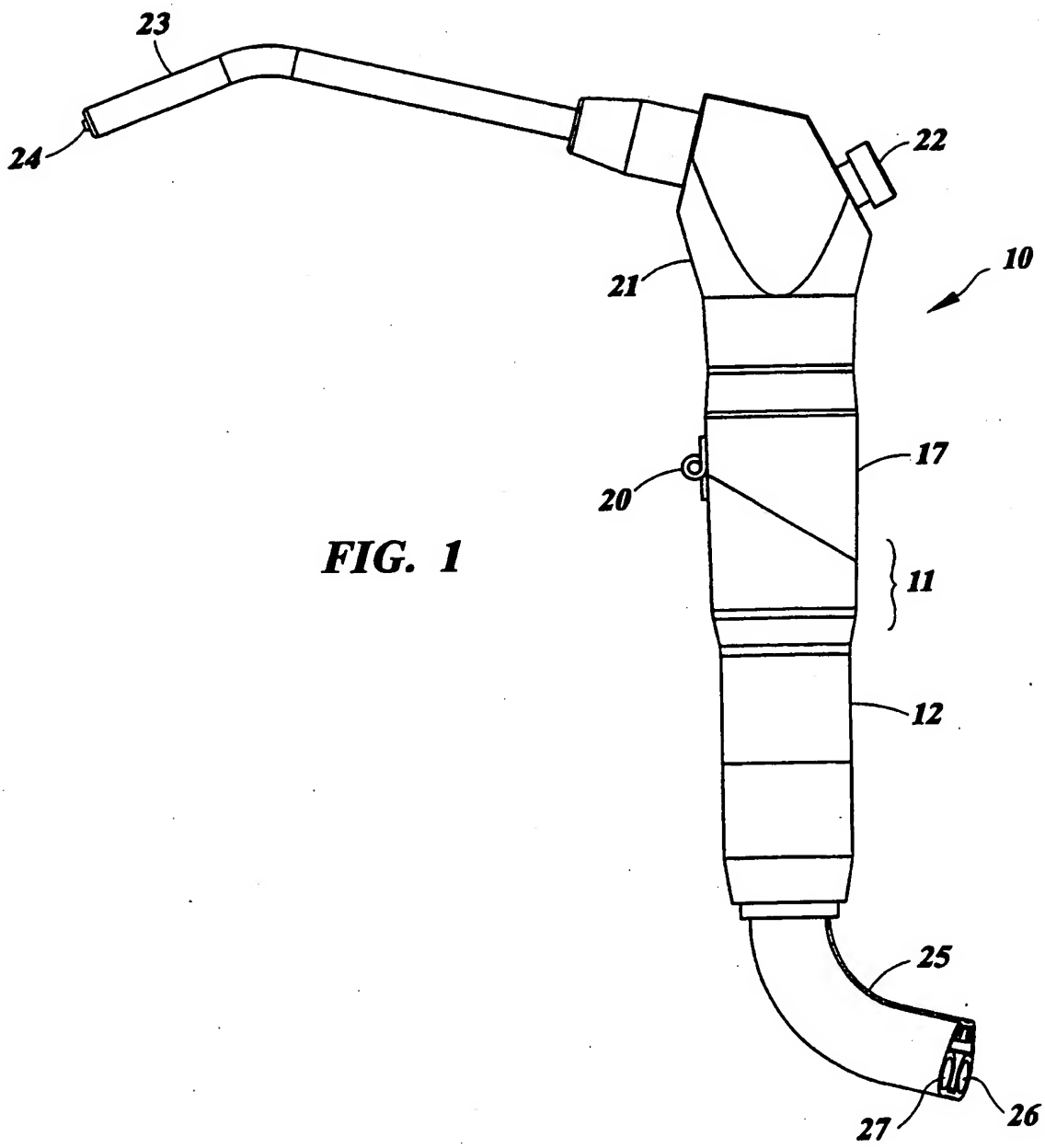


FIG. 1

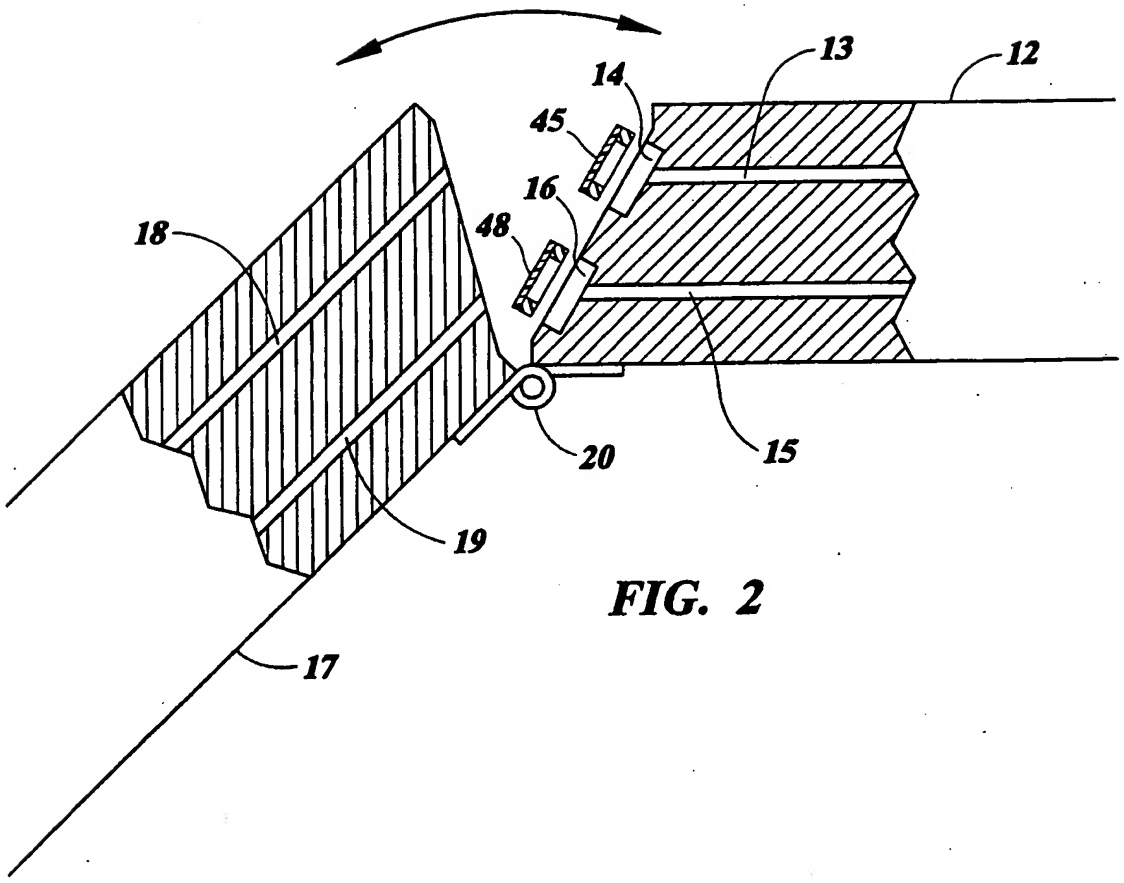


FIG. 2

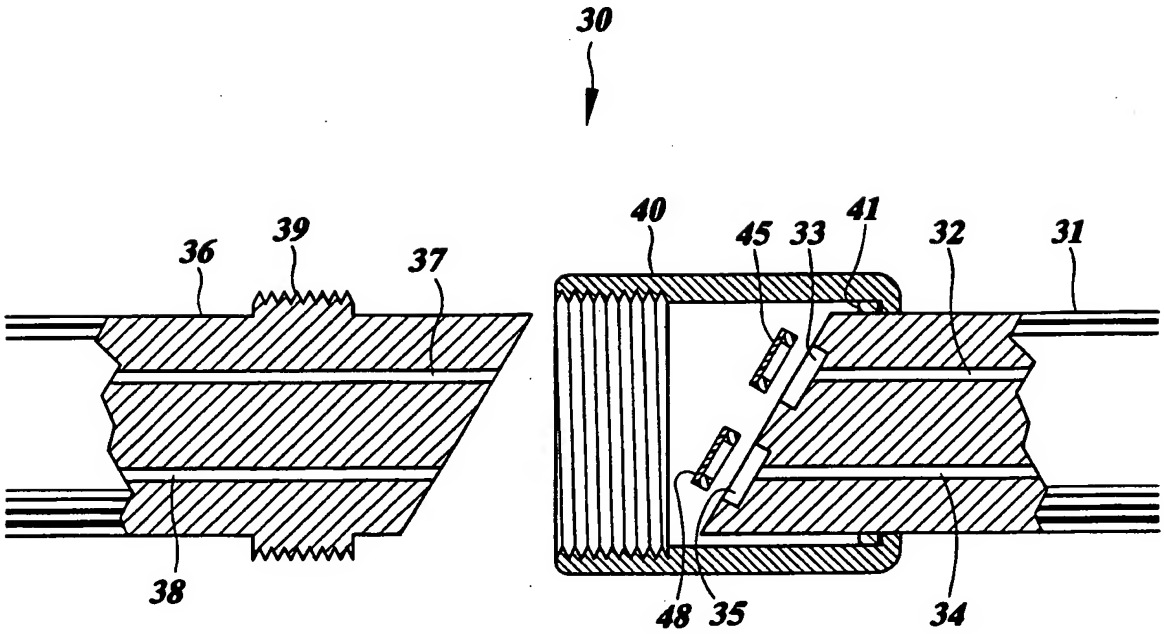


FIG. 3

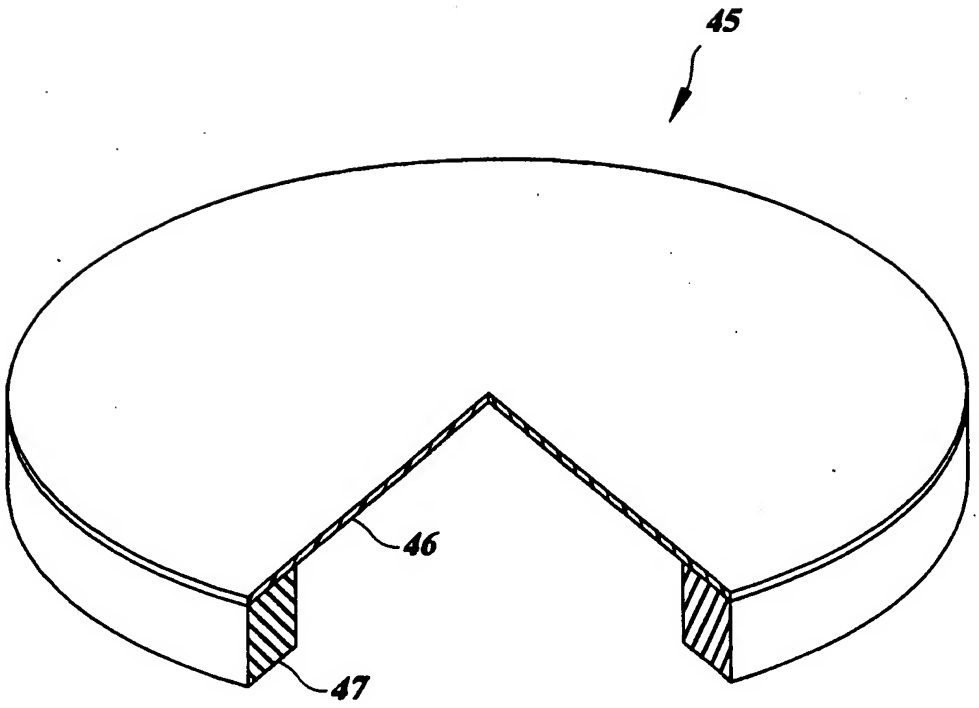


FIG. 4

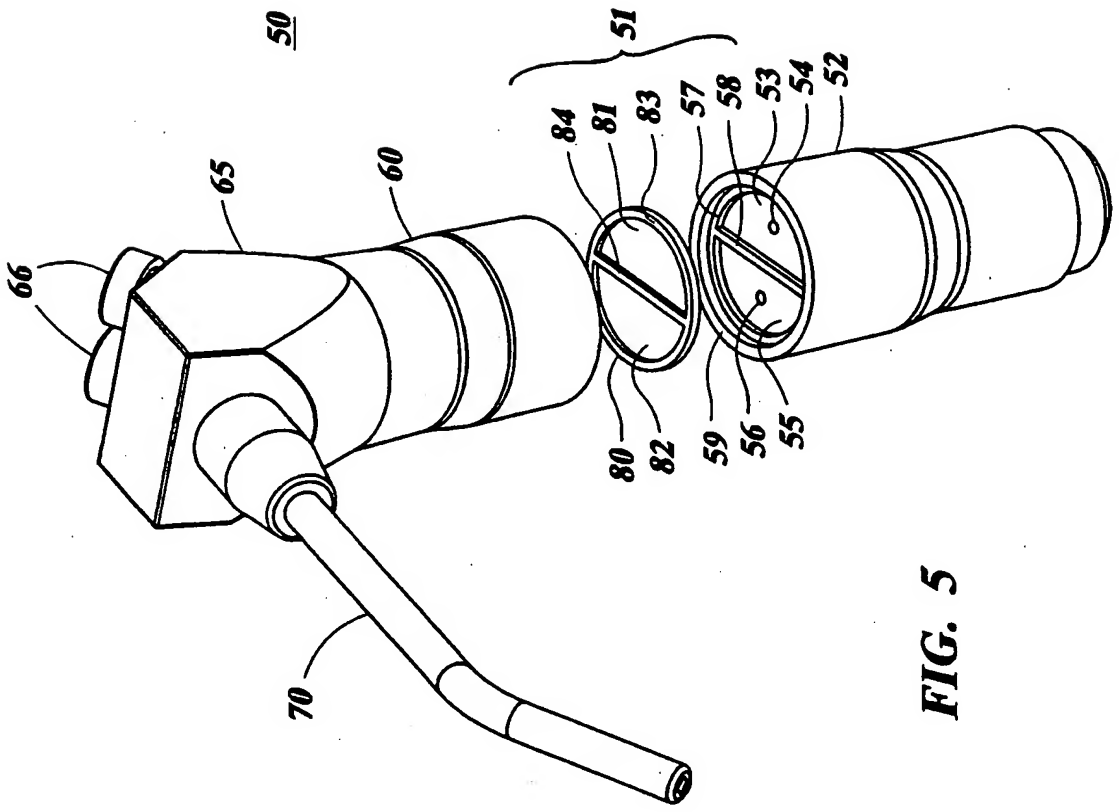


FIG. 5

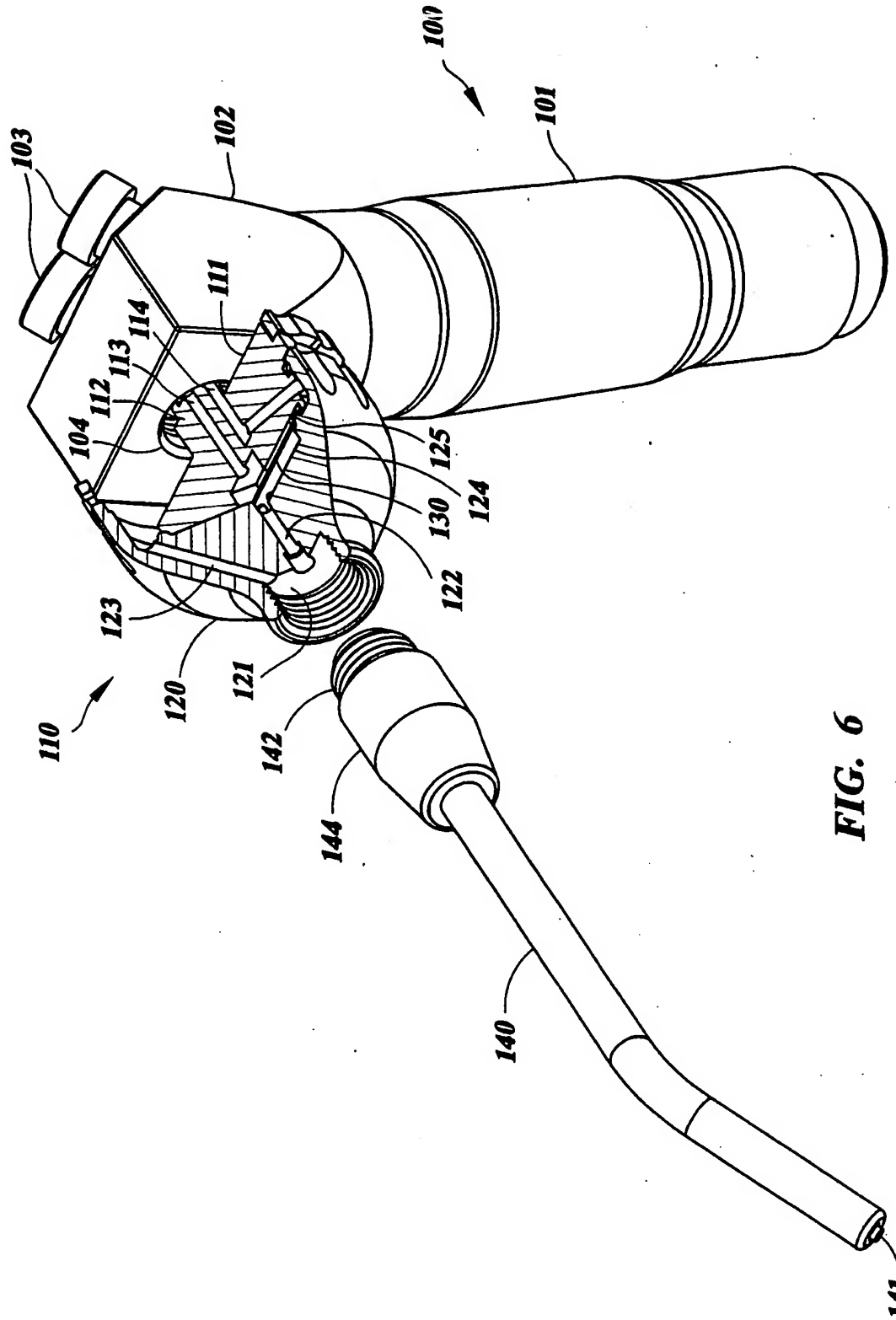

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FIG. 6

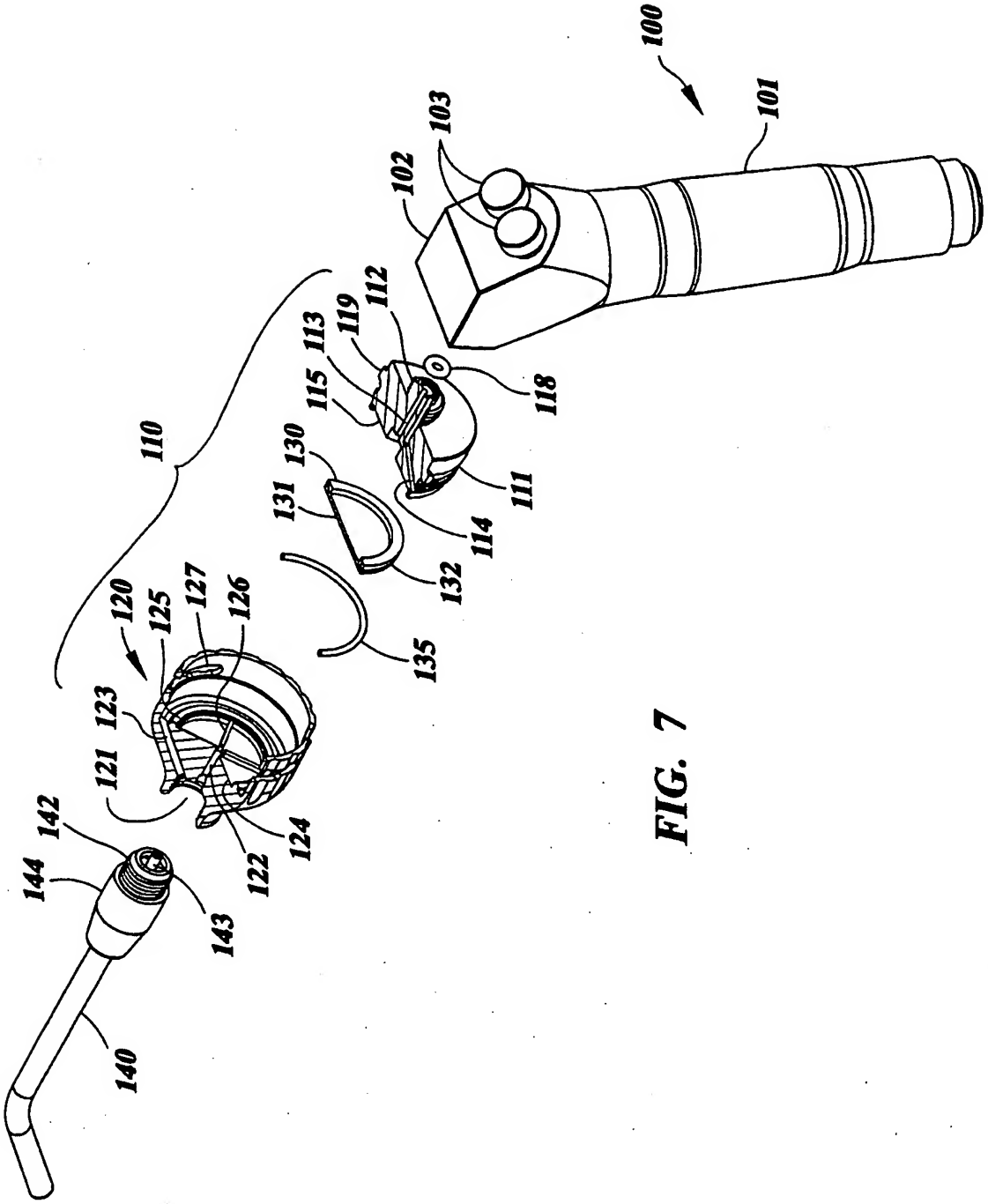
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FIG. 7

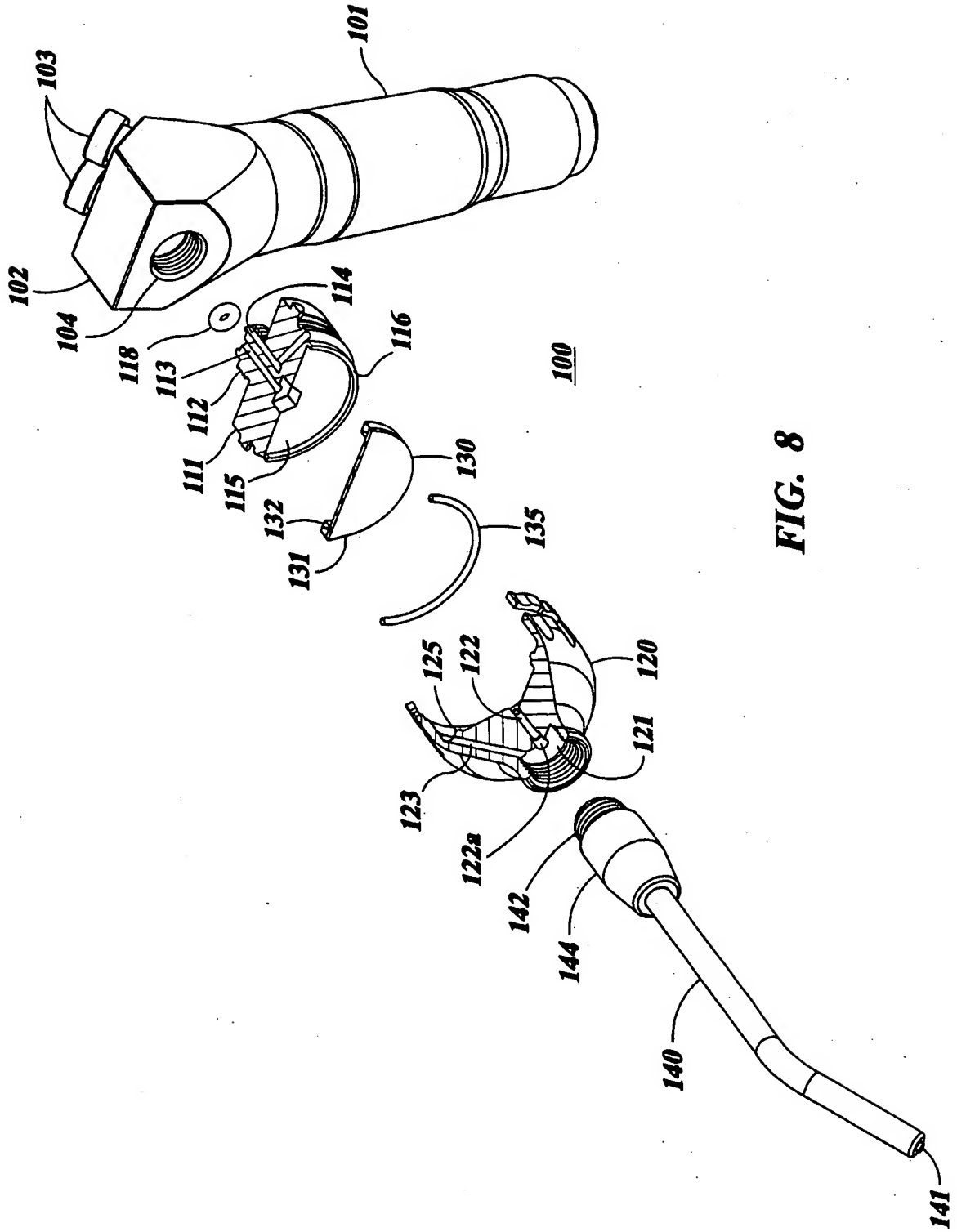
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FIG. 8

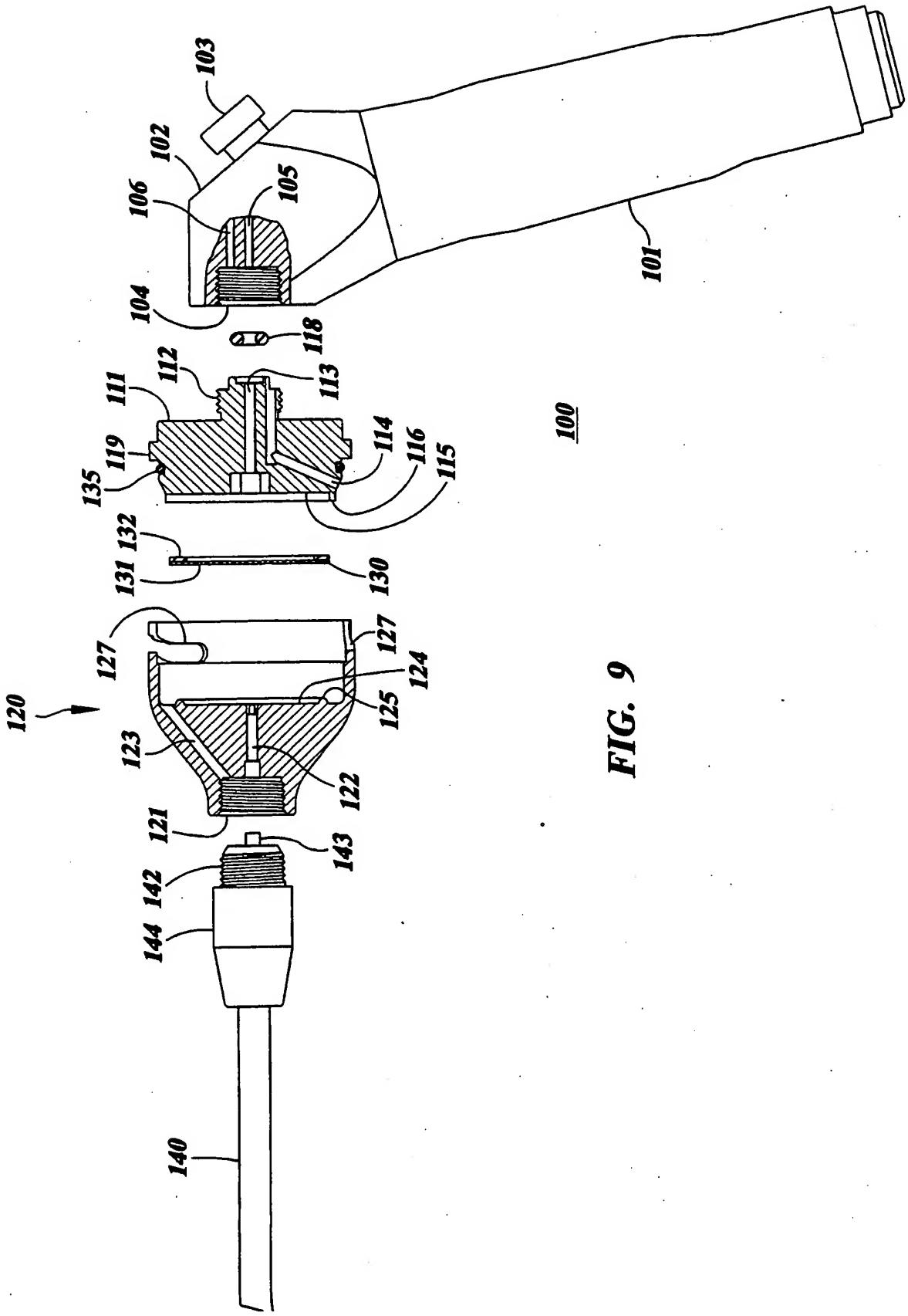
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FIG. 9

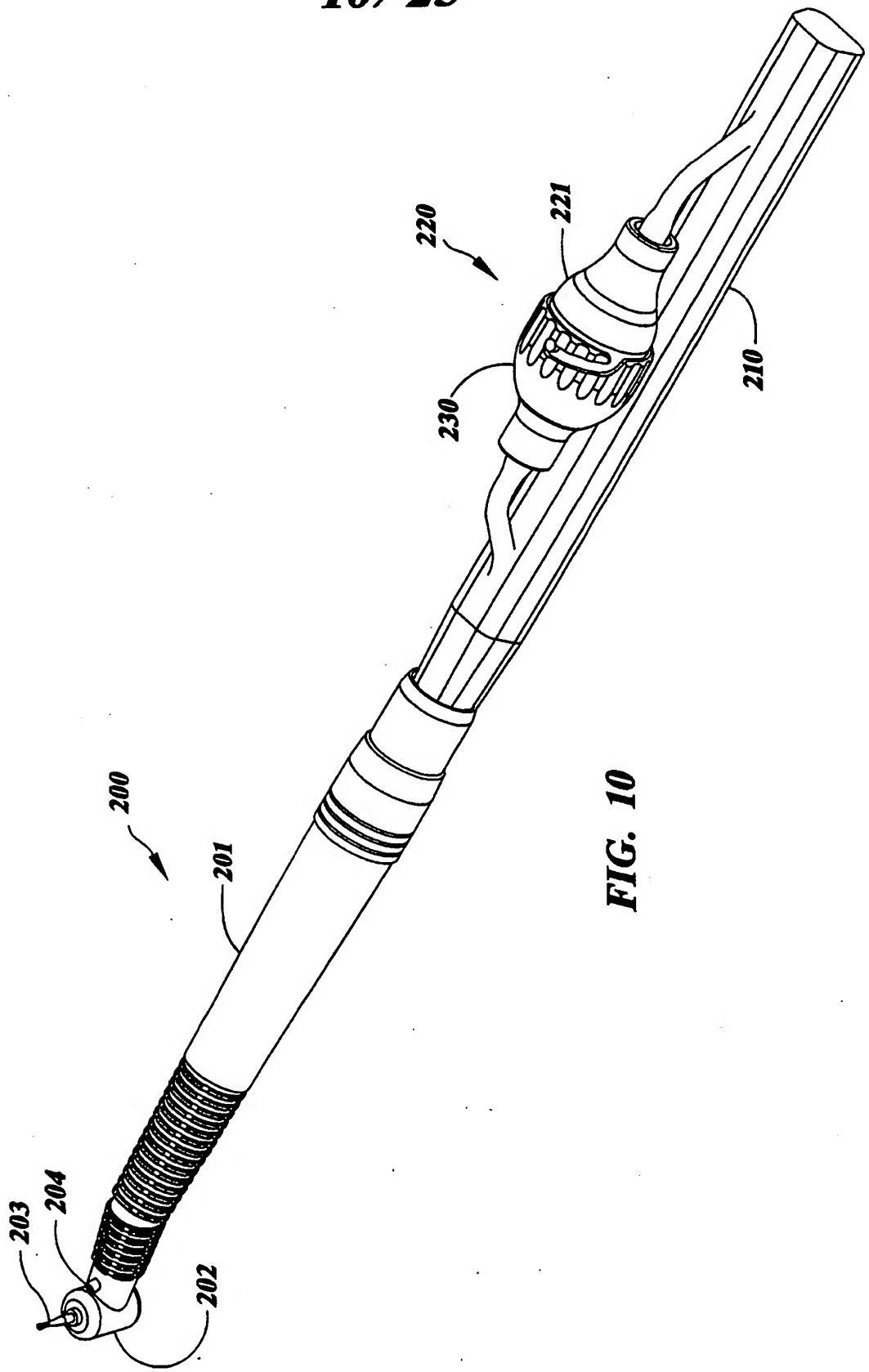

FIG. 10

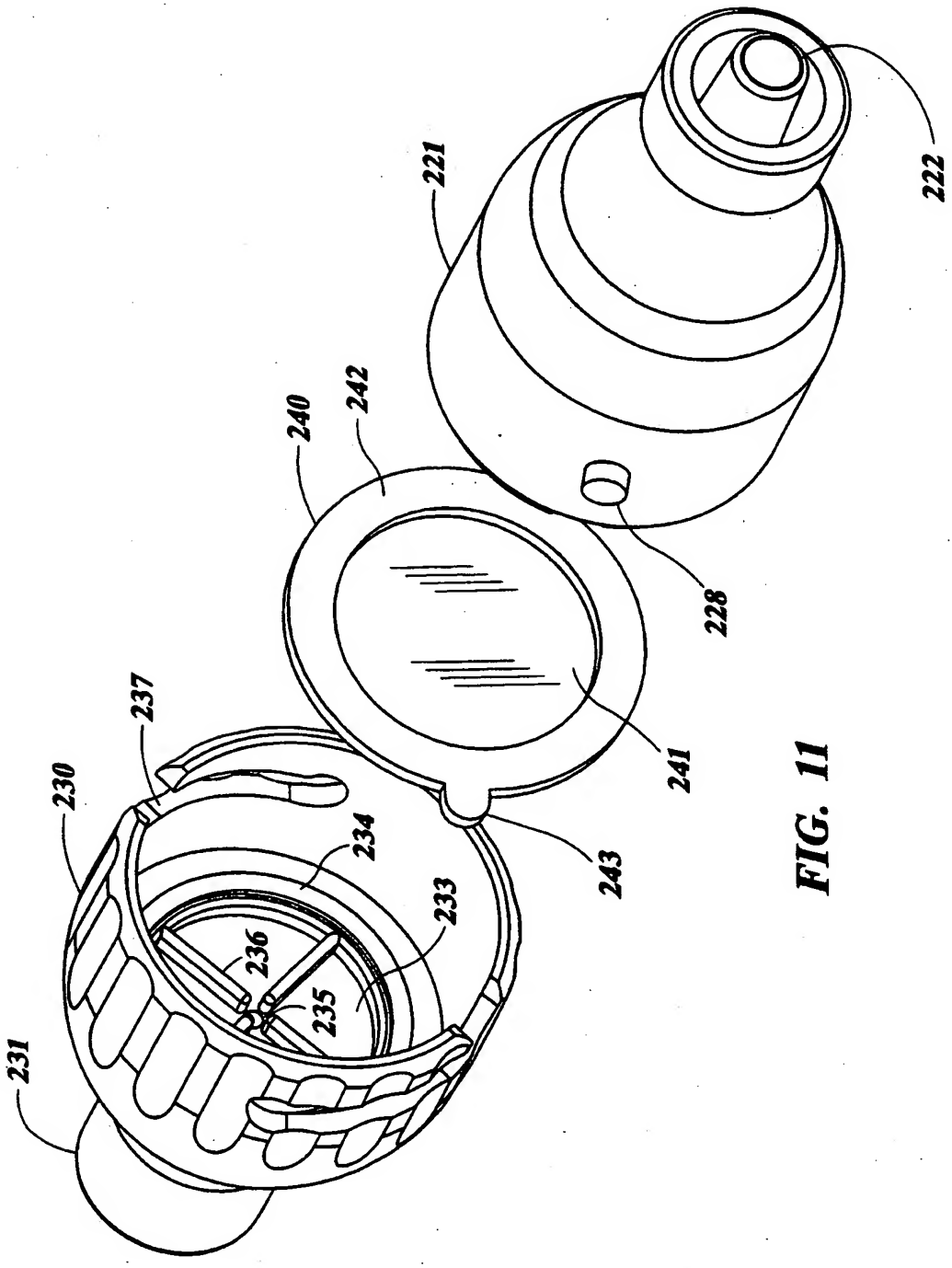

FIG. 11

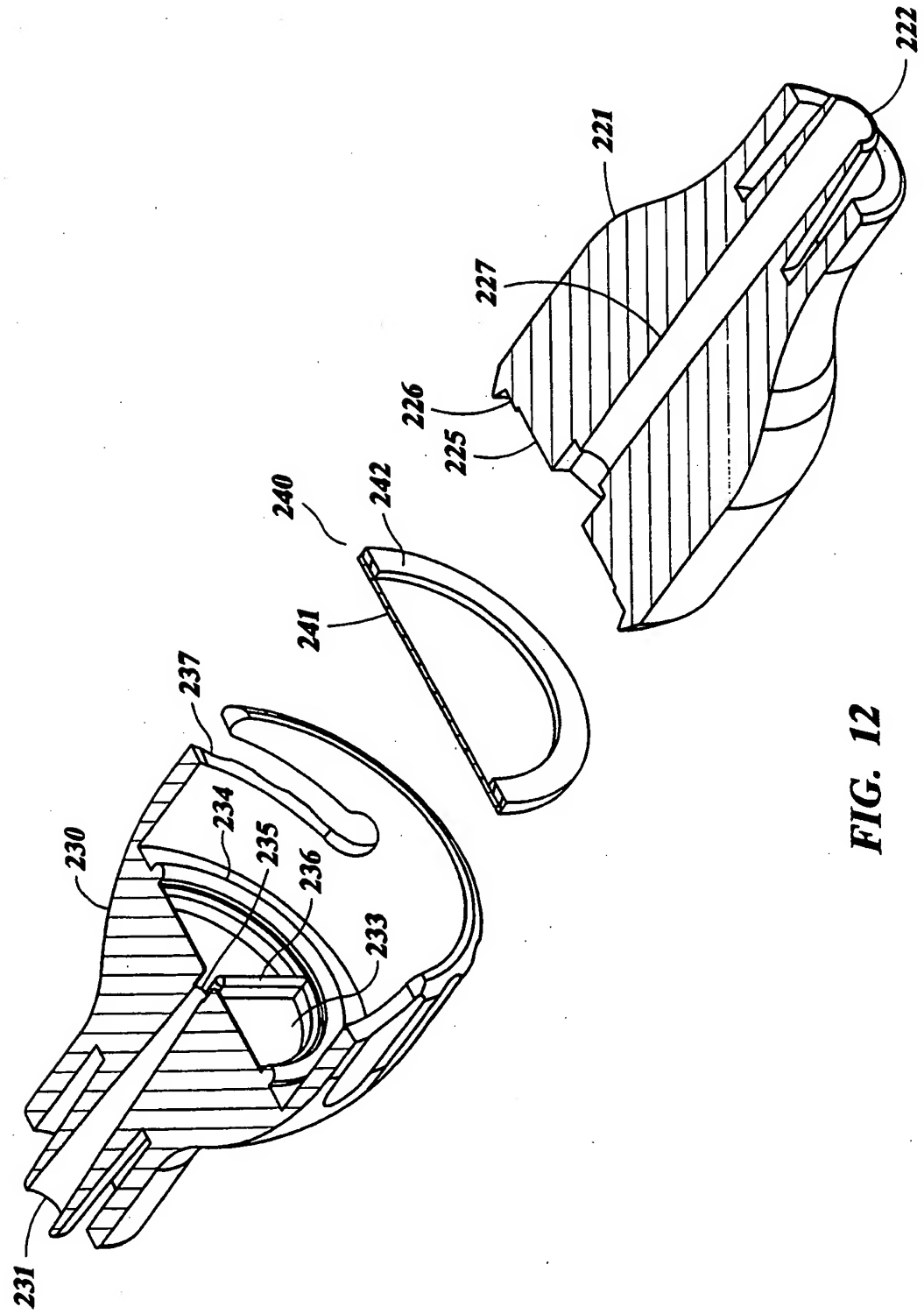

FIG. 12

FIG. 13

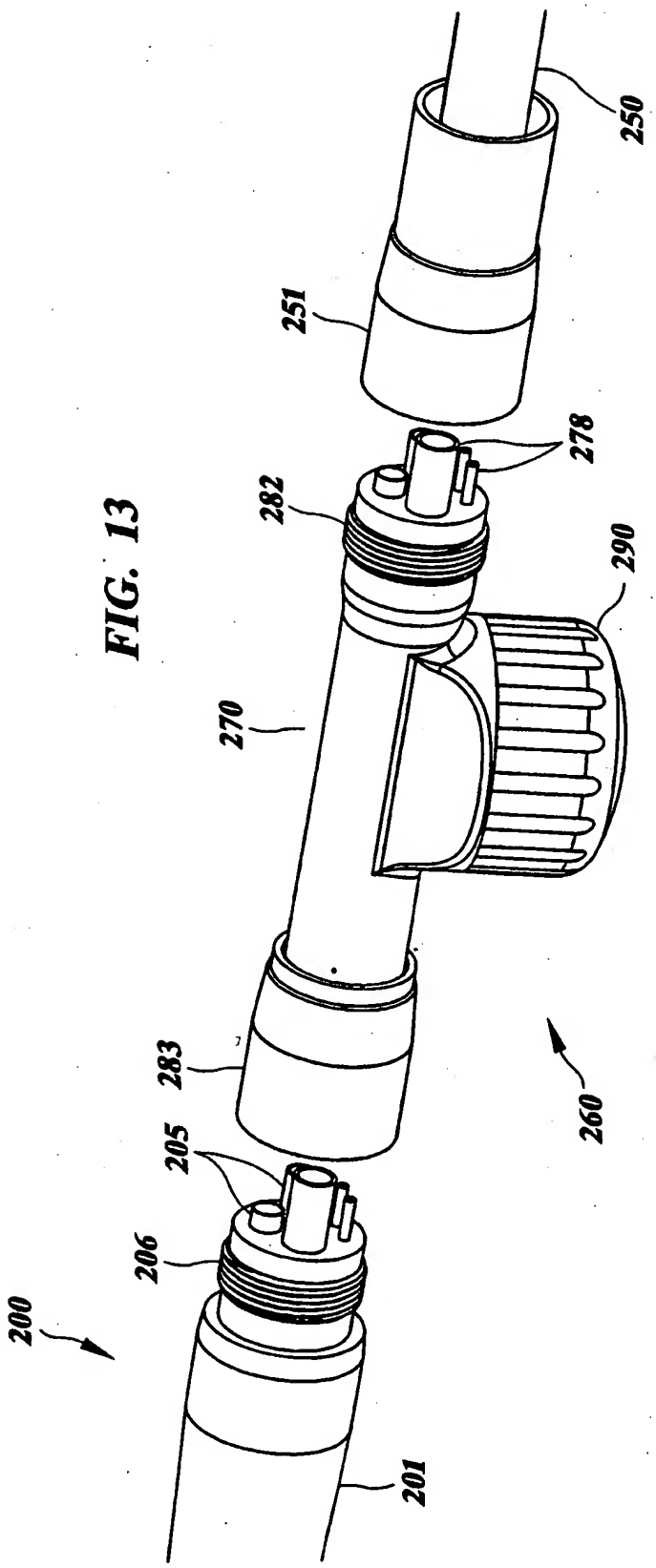

FIG. 14

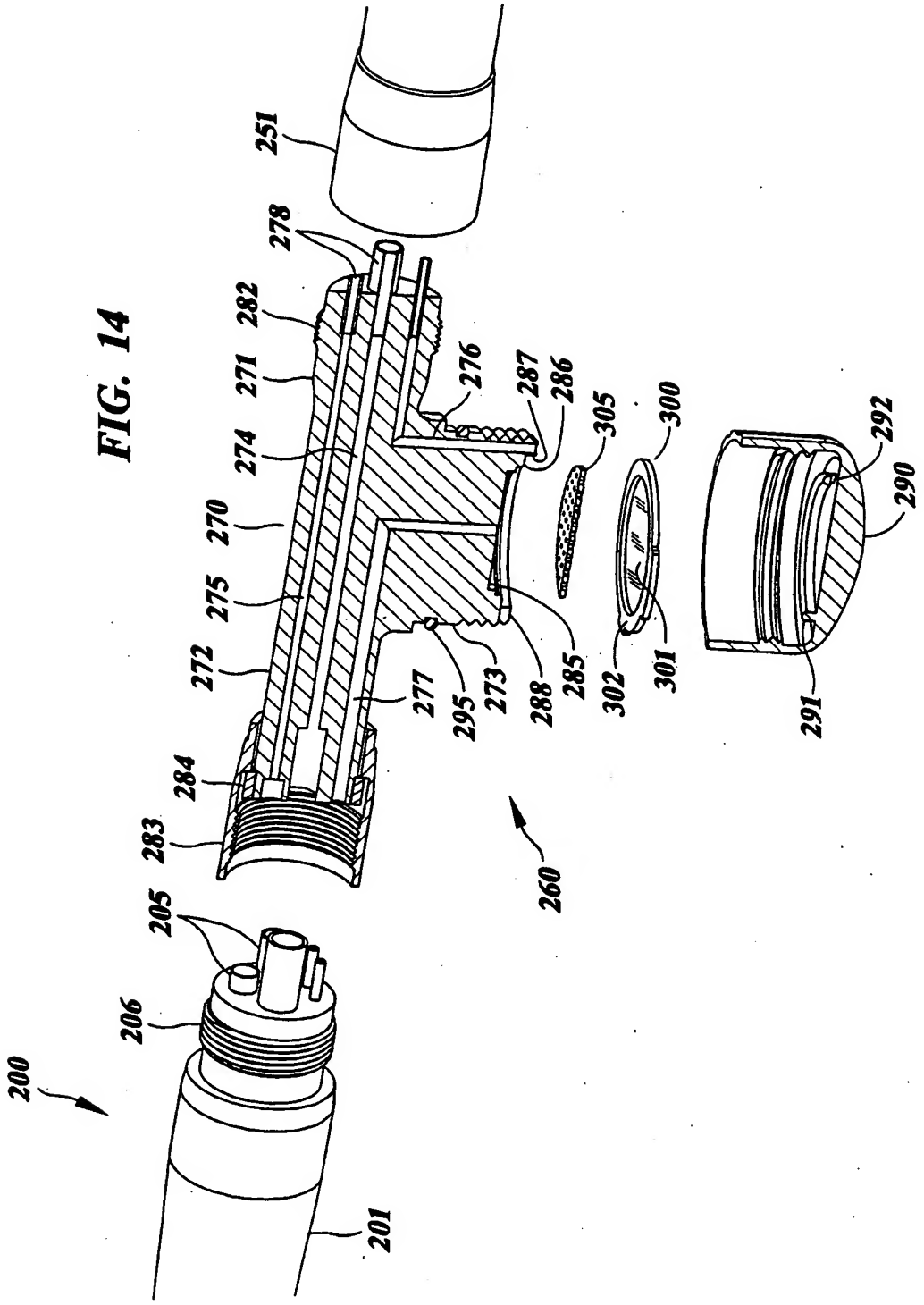
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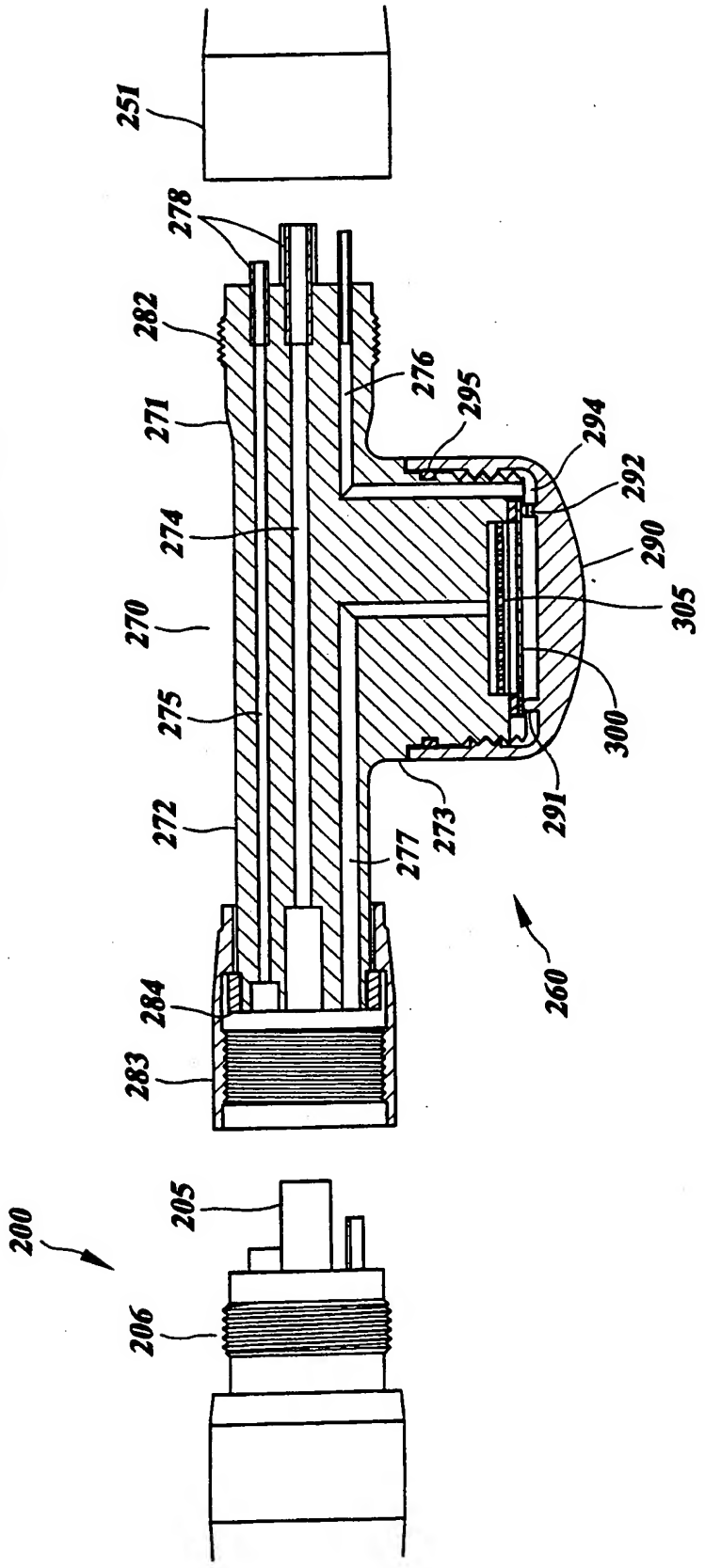
FIG. 15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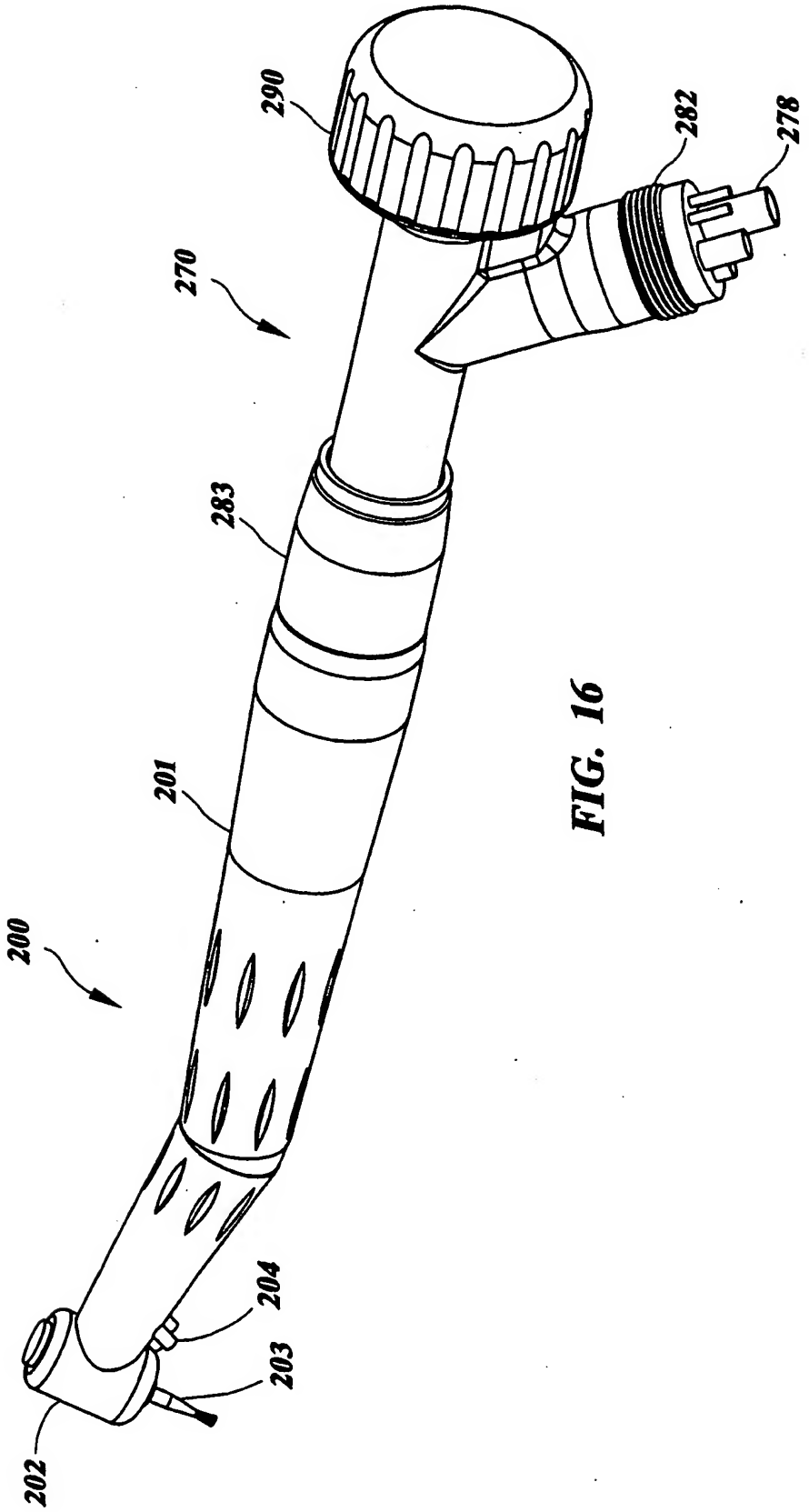

FIG. 16

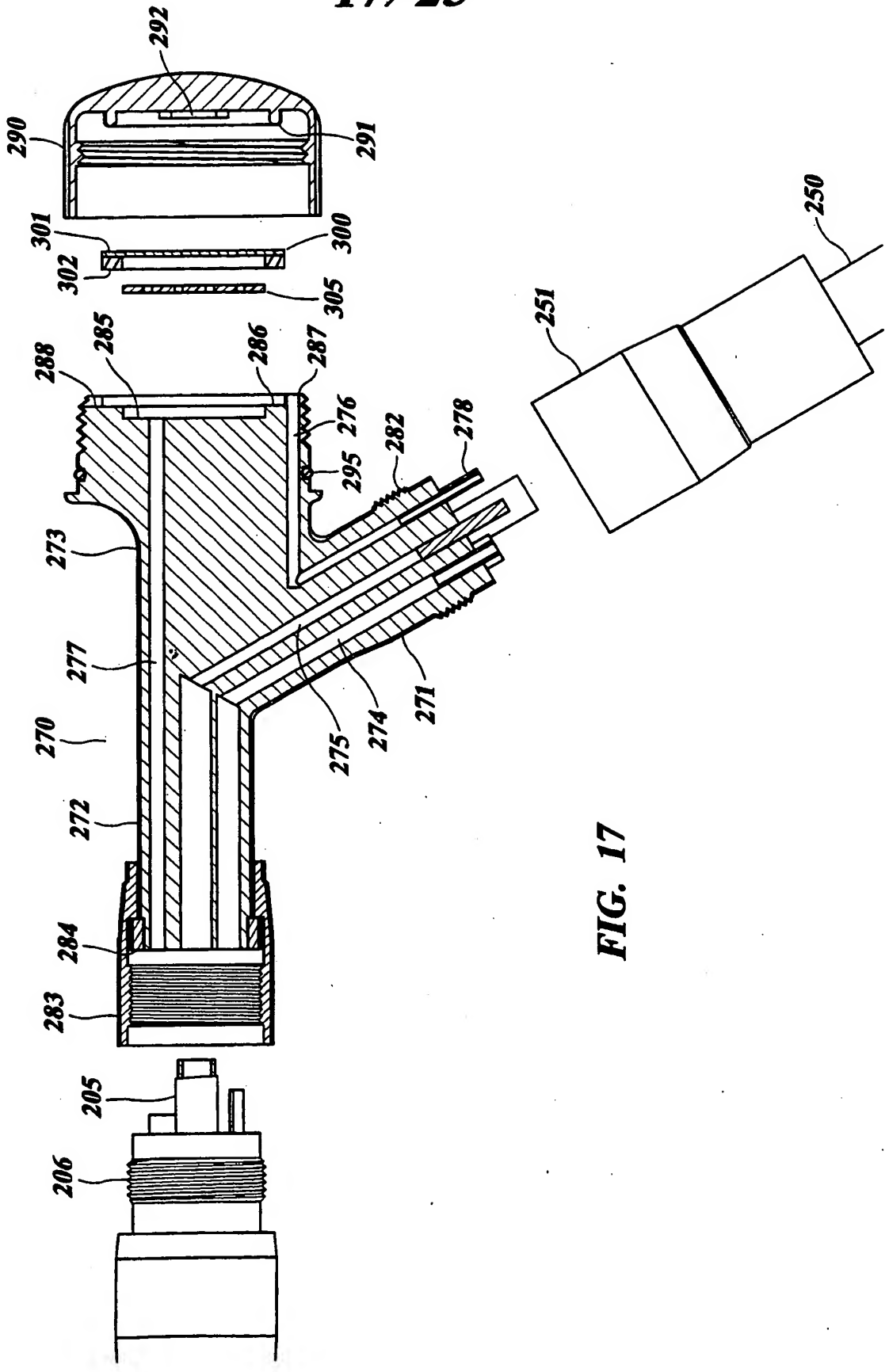
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FIG. 17

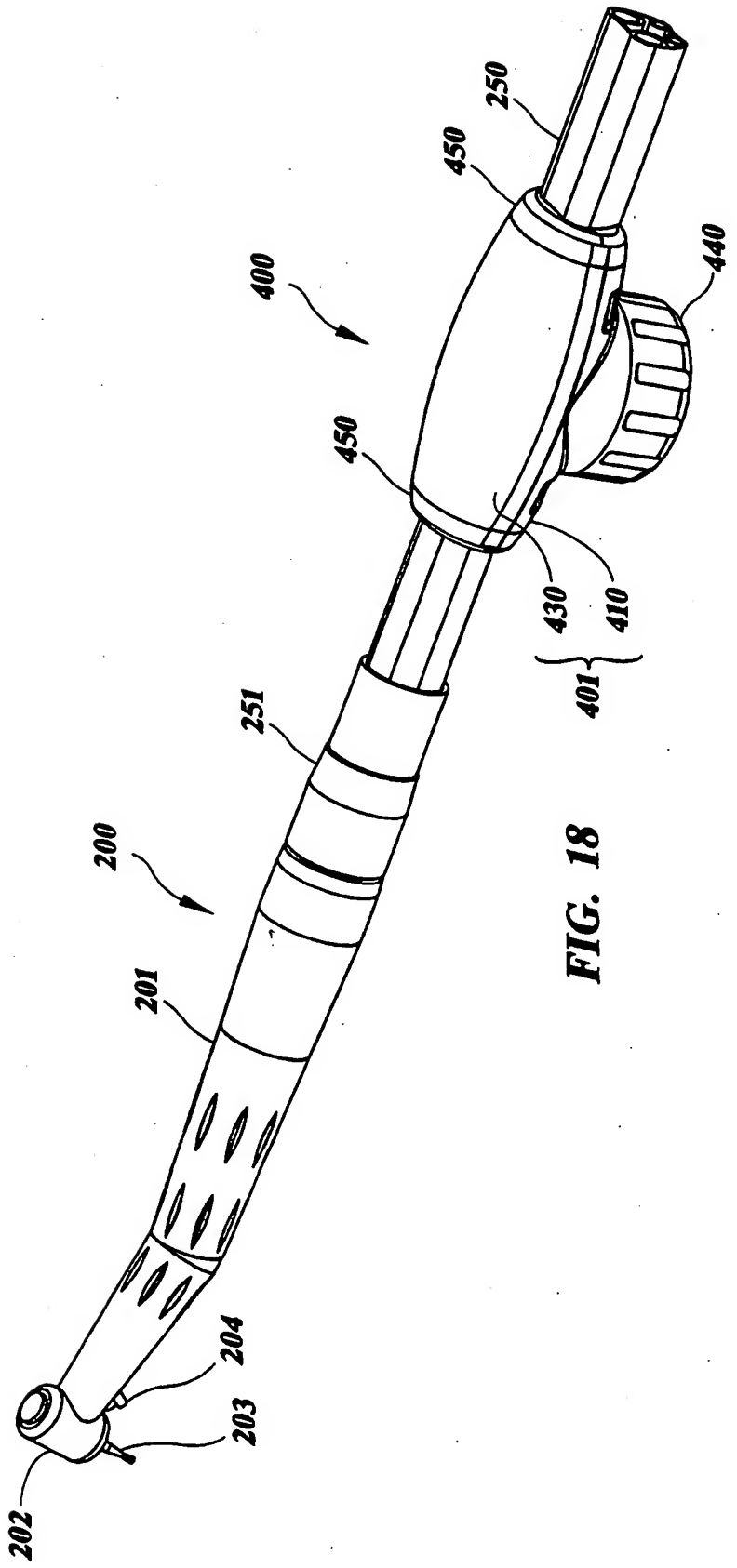

FIG. 18

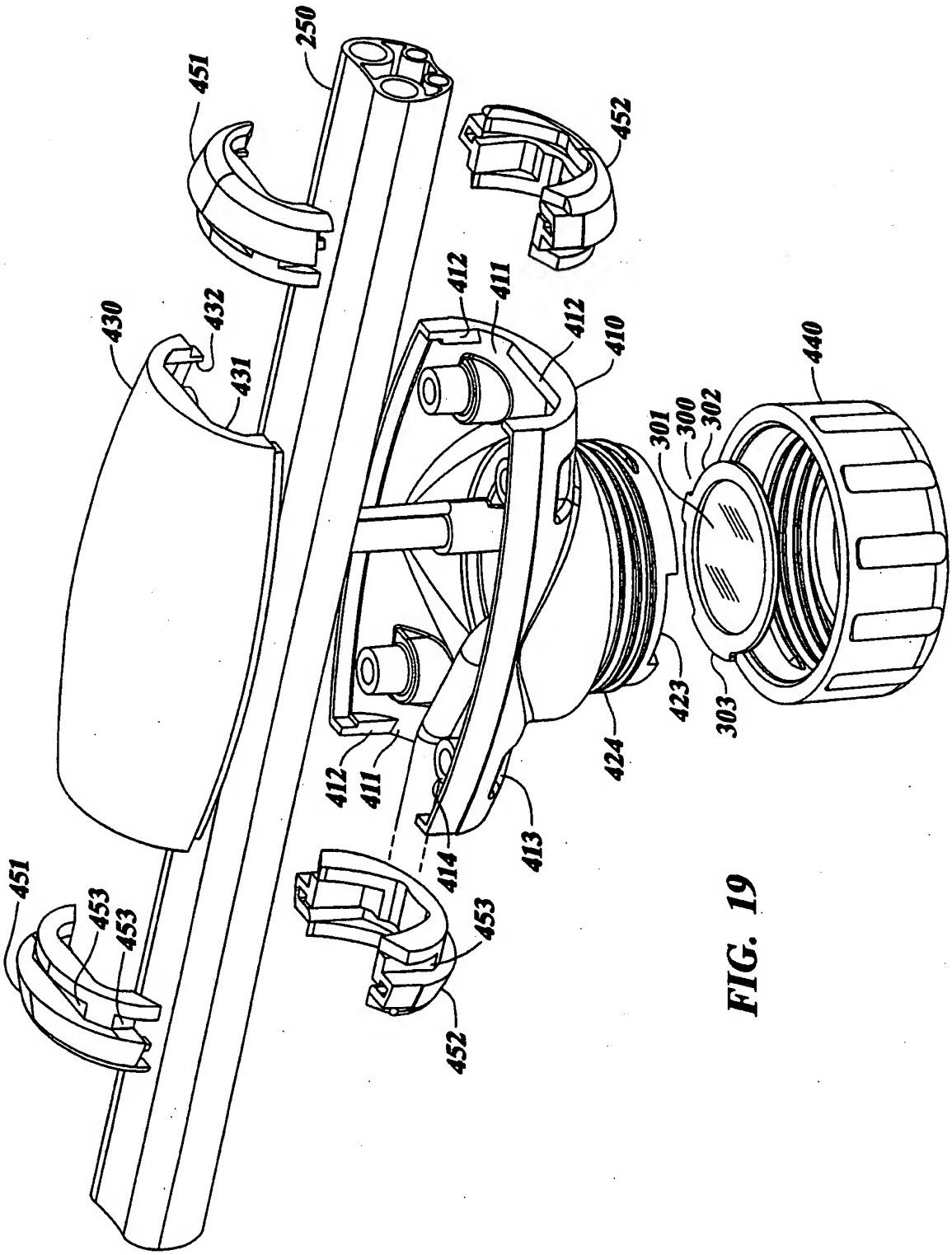
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FIG. 19

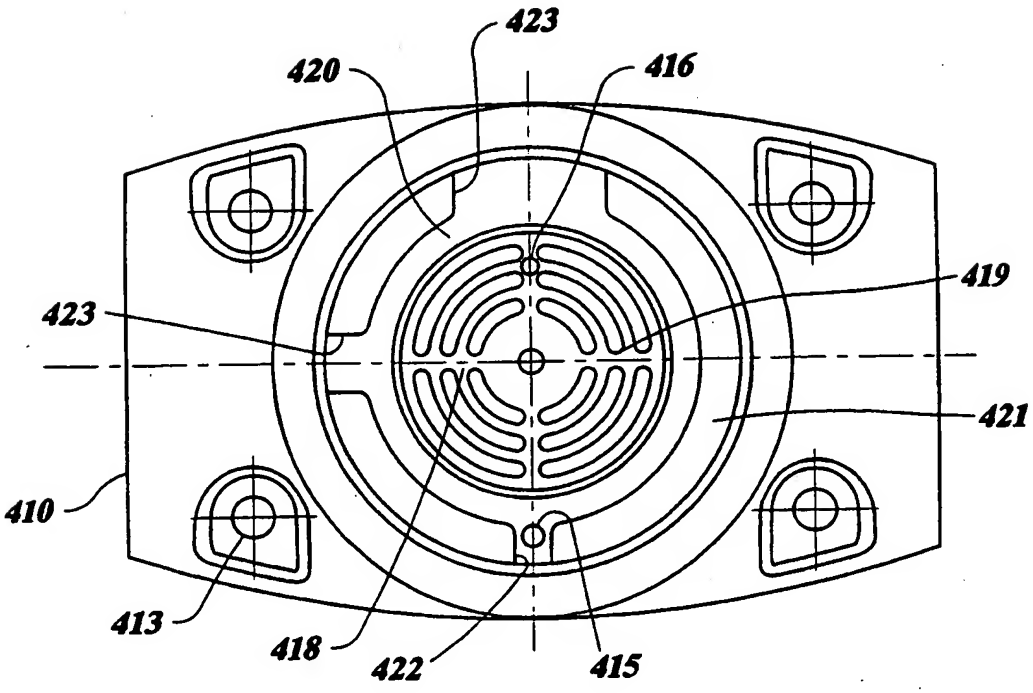


FIG. 20

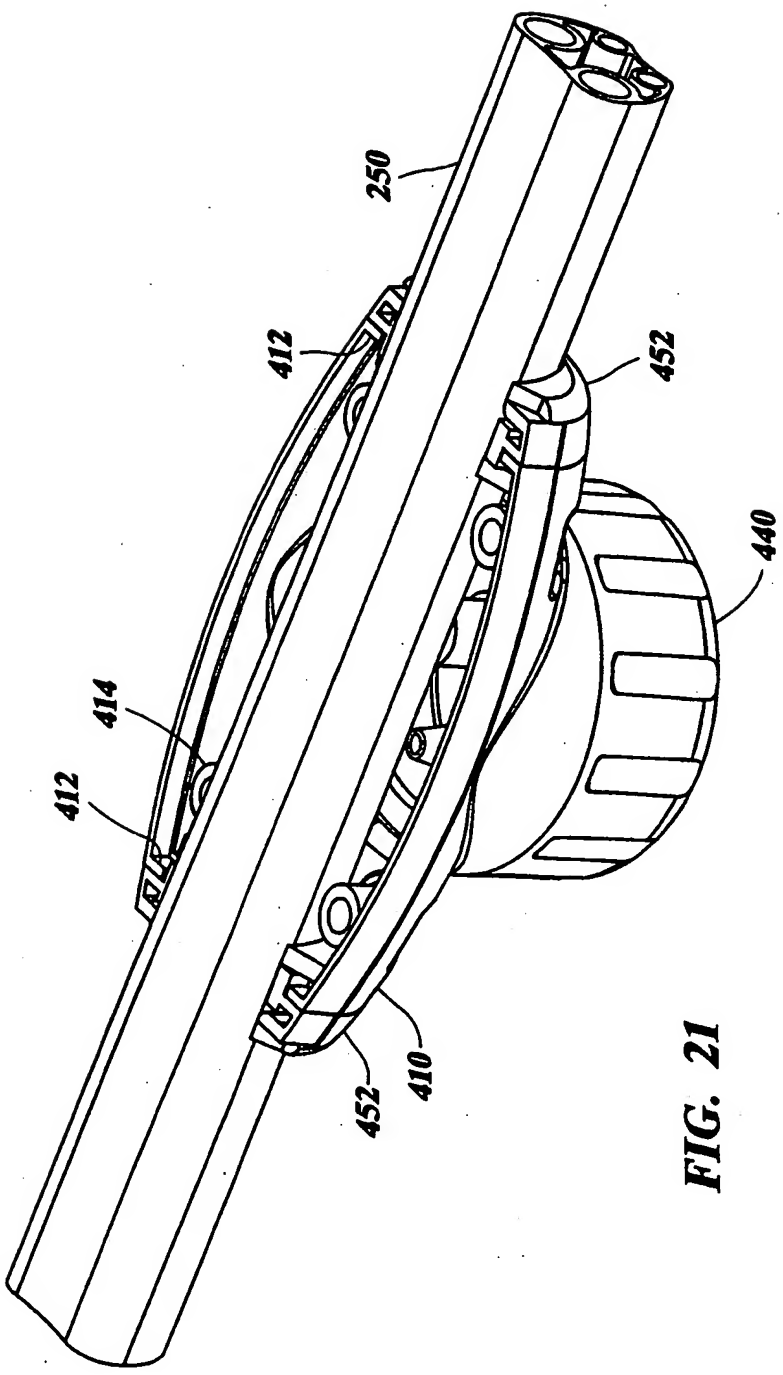


FIG. 21

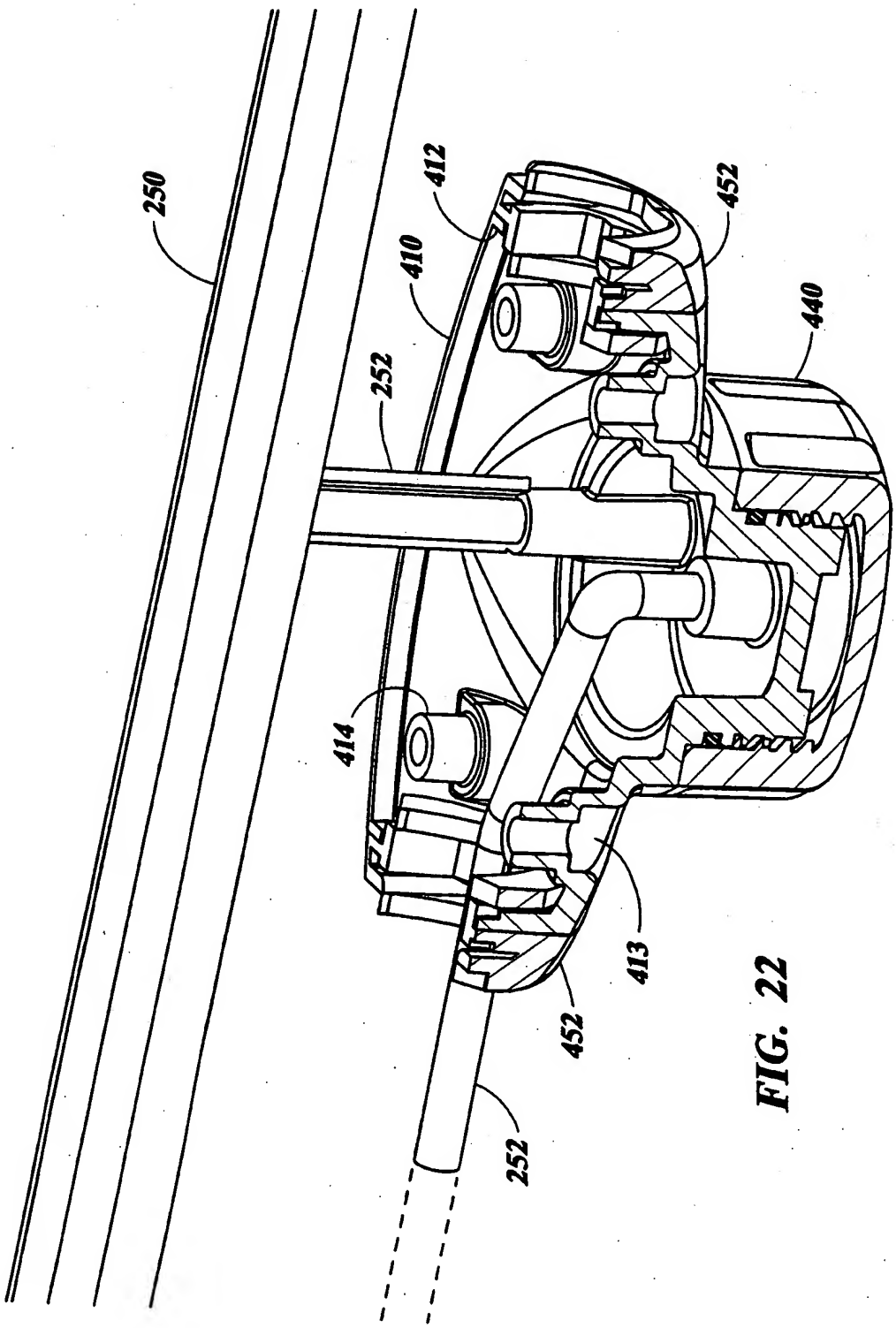
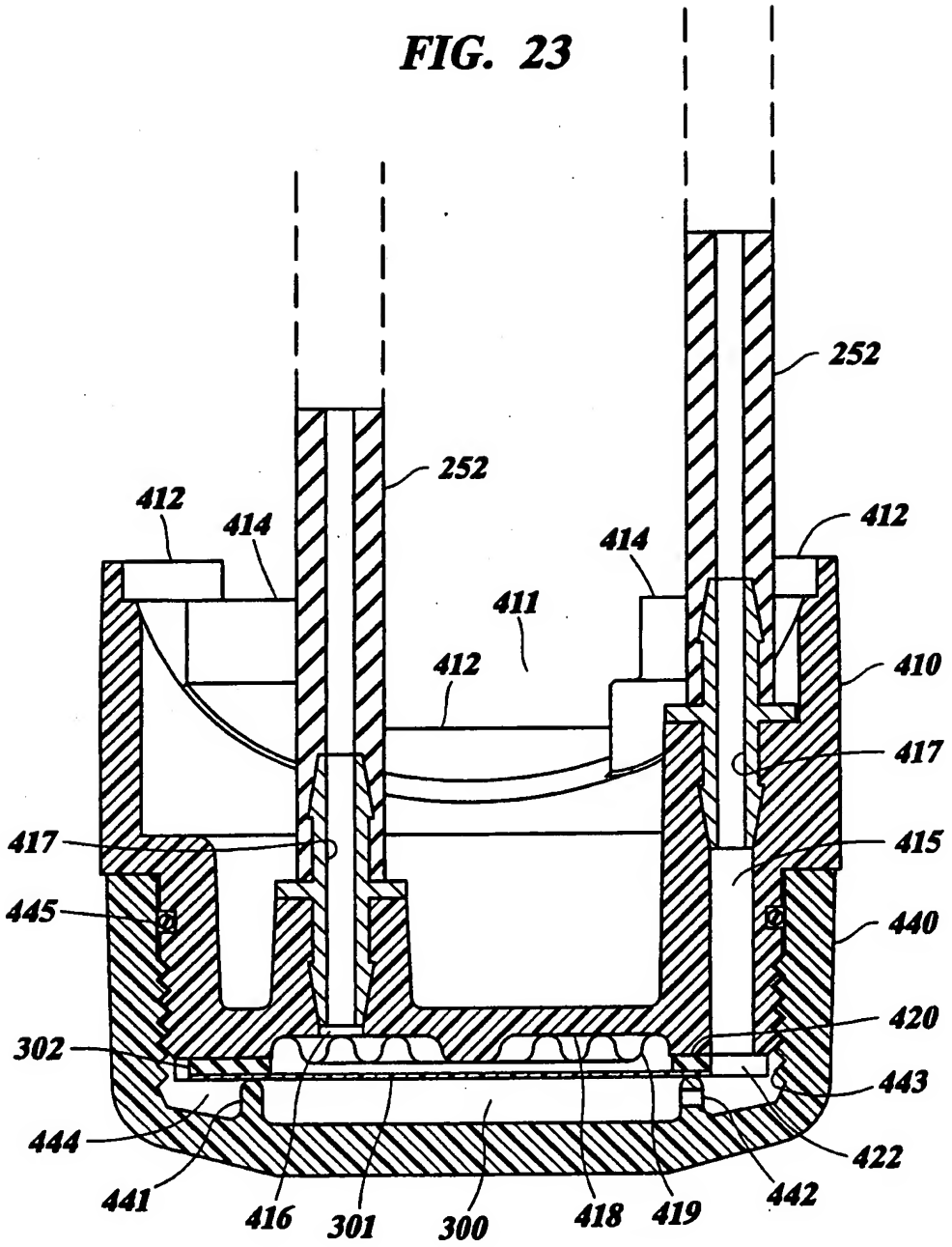


FIG. 22

FIG. 23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INTERNATIONAL SEARCH REPORT

Inter nal Application No
PCT/US 98/23537

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 A61C1/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 A61C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 96 26683 A (GELMAN SCIENCES) 6 September 1996 see page 6, line 28 - page 7, line 9 see page 13, line 11-30 see figures	1-5,7,8, 11-17, 19-22, 26-34, 40-61
A	--- -/--	23-25

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
19 February 1999	01/03/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Chabus, H

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INTERNATIONAL SEARCH REPORT

Inter ıal Application No
PCT/US 98/23537

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X	WO 97 16152 A (SCITECH DENTAL INC) 9 May 1997 see page 3, line 16 - page 4, line 5 see page 8, line 6-10 see page 8, column 28-36 see page 13, column 22-30 see figures 1,2,4,6,11	1-5,7,8, 11-22, 26-34, 40-61
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X	WO 95 20934 A (DALRYMPLE JON ;MAGNUSSON JAN H (US); UNIV MINNESOTA (US); MARTENS) 10 August 1995 see page 11, line 14 - page 12, line 20 see figures 1-3,12-15,21	1-5, 11-15, 17-21, 35-43, 47-58, 60,61

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INTERNATIONAL SEARCH REPORT

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